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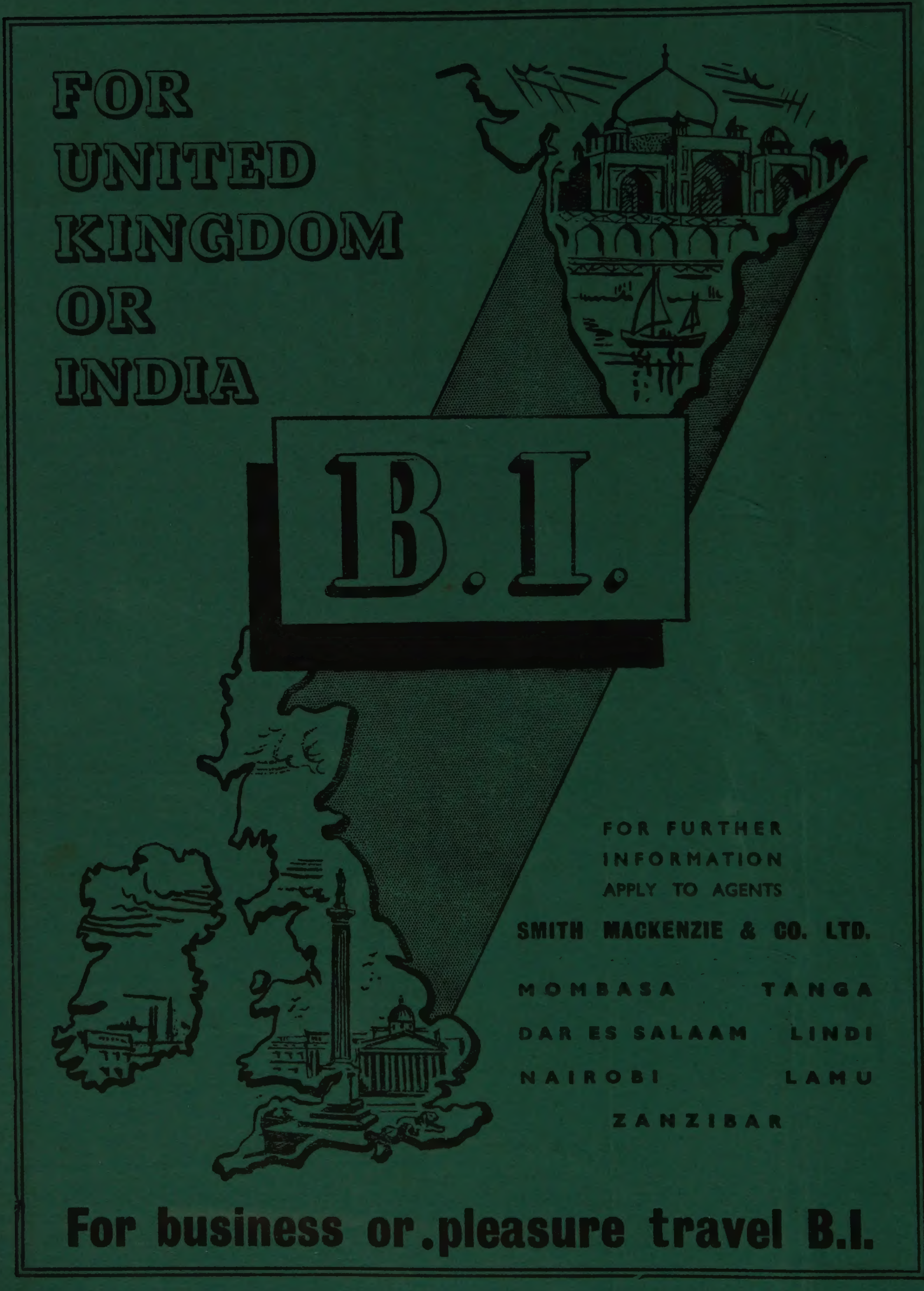
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Readers are reminded that all agricultural inquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

CONTENTS

INDEX TO ADVERTISERS

MOUND CULTIVATION

An article by Murray Lunan in this number describes the system of mound cultivation which is used by the Ufipa tribe in Tanganyika. The method is a combination of composting *in situ* and crop rotation, and, although no plant foods are added to the soil from outside the field, wastage of plant residues is avoided and the system is one which deserves more than passing notice. Briefly, the mound cultivation consists of piling cut grass into heaps and laying upturned sods on the top of the grass. This "compost heap" is then planted with beans and allowed to rot for nearly nine months, when the mounds are broken down and spread over the field.

This seems to be a simple and efficient method of conserving the organic matter in the soil, and it must produce a friable and absorbent topsoil. Since the mounds are about three feet in diameter, and only one to two feet apart, the dressing of composted material after breaking down the mounds must be very many tons per acre. The result of this is that the field may be cropped for several years before its productivity drops below an economic level.

As a relatively primitive system of native cultivation this is remarkably efficient, and in theory it is greatly superior to ploughing in of grass leys, since there must be a considerable heating and fermentation of the grass under the mound. It provides one answer to the problem of how to make the best use of plant residues, and it must greatly increase the penetration and absorption of rain during the wet season. The author mentions how, after the period of mound cultivation, the soil is cropped repeatedly until it is "exhausted" and has to revert to grass and weed fallow. This shows how the term "soil exhaustion" should not be used in the dictionary meaning of "total loss of strength", but rather in the sense of physical tiredness which can be cured by rest. But "resting" of a soil consists of allowing other plants, chiefly grass and trees, to grow, so there is no cessation of plant growth, and one of the most important scientific problems in tropical soil science is to substitute for the slow natural fallow economic crops which will have the same effect of restoring the "strength" of the soil. Cultivated grass leys seem to provide the best answer in modern agriculture, and these have been proved and adopted in some parts of East Africa, but suitable grasses and methods have not been found for the drier areas.

It is interesting to note that the Ufipa tribe plant legumes on the mounds while they are decomposing, thereby making use of the soil at a time when plants would be liable to nitrogen starvation because of the demand for nitrogen by the decomposing organic matter. In the later stages of the rotation, too, legumes play an important part in mixed cropping, and it is clear that this tribe have discovered for themselves the importance of nitrogen in the crop cycle. Sufficient basic knowledge of soil nitrogen is not yet available to judge the real value of the leguminous crops in this system of agriculture, but it may be that omitting them in the rotation would greatly reduce its success. If the principles of the method were fully understood, they would throw some light on the fundamental problem of soil fertility in the tropics.

It is generally agreed that microbiological activity plays an important part in tropical soil fertility, even although fundamental knowledge of the subject is scant. In this system of mound cultivation microbiological activity must be encouraged to a much greater extent than if the grass was merely hoed in, since moisture and heat will be retained to some extent at least. It therefore seems reasonable to suppose that by shallow ploughing of a grass ley to turn over the sod in high wide ridges there should be greater encouragement of bacterial life than by ploughing in the ordinary way. One of the difficulties with grass leys and green manuring in the tropics is the fact that the organic matter is frequently ploughed in about the end of the rainy season, and by opening the soil there is a tendency for it to dry out rapidly and to leave insufficient moisture for decomposition of the plant material.

Whatever the theoretical explanation of this mound system of cultivation, the fact remains that we have in it a practical method of conserving the organic matter in the soil, and it deserves further study as regards both theory and practice. Soil fertility studies in the tropics have tended to be based on the adaption of methods which have been successful in temperate climates, but here we have an opportunity of improving on a native practice by mechanizing it, if that is possible, and by applying fertilizers to the decomposing organic matter. It is extremely unlikely that this method, as it stands, would willingly be adopted by other tribes, but it might form the starting point from which to work out a practical system with wide application. Organic matter must have its place in tropical agricultural practice, but the application of cattle manure in four-gallon kerosene tins is no longer economic.

Ufipa is by no means the only tribal district in East Africa where organic matter is returned to the soil. In this Journal (Vol. 10, 1944, p. 22) A. S. Stenhouse describes the pit system of cultivation employed by the Matengo tribe in South Tanganyika. The grass is cut and laid in rows forming a grid, and the soil between the rows is dug out and pulled on top of the rows of grass. When this work has been completed, the surface of the field is pitted where the squares have been, with ridges of soil between the pits underlain by a layer of grass compost. The pits are four to five feet across and so are the beds. In the crop rotation maize is alternated with peas and beans, and all weeds are thrown into the pits, where they rot down with the accumulating silt. At the end of each season, crop residues are also deposited in the pits, the old soil beds are split, and the new beds are formed over the old pits: the news pits occupy the places where the old beds intersected. By this means, careful cultivators can keep their land under cultivation for eight to ten years before fallowing is necessary.

The Matengo pit system adopts the same general principles as the Ufipa mound system, by composting all plant residues *in situ* and rotating grain crops with legumes. In the Matengo method, however, prevention of soil erosion is also necessary, since steep hillsides are cultivated and there is danger of losing much of the soil. The alternating ridges and pits are effective in conserving rainfall and in preventing erosion.

While some native tribes have taken great pains to conserve the organic matter in the soil by making full use of all plant residues, others have taken even greater pains to burn trees, branches and brushwood on the site before planting. The Chitemene system, in Northern Rhodesia, involves clearing up to ten acres, piling the woody material on one acre, and producing a very hot burn on the area to be cultivated. Burning has been practised since time immemorial, but it is not usually carried out with such care and hard work as in the Chitemene system. It is somewhat remarkable that the effort required in the latter method is very much greater than that in the Ufipa and Matengo systems, but it would be dangerous to assume that mound or pit cultivation would be successful in areas where intensive burning is practised. On the other hand there is no doubt that the Chitemene and similar methods are wasteful, and do not make the best use of the land.

It has been suggested, and it seems probable, that the Chitemene system owes its success to partial sterilization of the soil, resulting in rapid growth of those organisms which are most beneficial to plant life, and it is likely that the mound and pit methods also encourage microbiological activity. Thus it is possible that these two widely differing agricultural systems lead to the same end, and microbiological investigations might go far in explaining the theory of their success.

D.W.D.

NOTICE

The Directory of Veterinary Services, P.O. Kabete, Kenya, wishes to purchase Vol. 7, No. 2 (October, 1941), of this Journal, in order to complete the set in his Departmental Library. Anyone willing to sell this number should write direct to the above address.

CONDITIONS AFFECTING THE EAST COAST FEVER PARASITE IN TICKS AND IN CATTLE

By E. Aneurin Lewis, East African Tsetse and Trypanosomiasis Research and Reclamation Organization, Nairobi*

(*Received for publication on 21st July, 1950*)

Lewis and Fotheringham (1941) showed that *Theileria parva*, the causal protozoan parasite of East Coast fever of cattle, does not always live as long as the tick (*Rhipicephalus appendiculatus*) which it commonly infects. The results of their experiments indicated that batches of ticks which had been infected were incapable of transmitting East Coast fever after they had been kept unfed at room temperatures of 19° to 22° C. (66° to 72° F.) for about 350 days after moulting. Ticks, from the same infected batches, tested at short periods of starvation, invariably transmitted the disease when fed on susceptible cattle.

Age of the Moulted Infected Tick

The parasites in the ticks were apparently destroyed in the course of prolonged starvation or, at least, they were rendered innocuous when transferred to cattle.

The number of cattle used to feed starved ticks was, up to that time, small; and it was considered desirable to continue the observations in order to confirm or to modify the earlier conclusions; and to determine whether or not the parasites, at some late stage in the life of the unfed ticks, would provoke only a mild form of East Coast fever resulting in recovery and a high degree of immunity of the bovine host. The results of the additional experiments are tabulated in Table I.

The data given in this table confirm the earlier observations with regard to the limits of survival of *T. parva* in nymphæ and in adults of *R. appendiculatus* fed as larvæ and nymphæ respectively on cattle reacting to East Coast fever.

Not a single batch of infected ticks, kept unfed for over 350 days after moulting, has yet transmitted the disease. On the other hand, batches of infected ticks starved for less than 266 days have hardly ever failed to convey the disease to susceptible cattle. Those starved from 266 to 348 days gave mixed results: some provoked a fatal attack of East Coast fever; some, a mild form of the disease; and others had clearly lost their infectibility before the expiration of 350 days.

It is evident that the age of the moulted tick, or prolonged starvation at the room temperatures specified contributes to the destruction of the parasite in its tick host, or to its inability to cause the disease when transmitted to cattle.

Other observations on *R. appendiculatus* exposed to natural conditions in small paddocks at the Veterinary Research Laboratory, Kabete, have shown that the adult ticks will live as long as, and sometimes longer, than specimens kept in tubes under laboratory conditions. The mean monthly temperature in the paddocks ranged from 17.7° to 24.1° C. (64° to 75° F.) and the period of exposure was, in this case, unusually dry. The parasite of East Coast fever in such ticks disappears as it does in ticks kept at room temperatures.

The results obtained by feeding infected ticks which have been starved from 266 to 348 days throw some light on the incidence of East Coast fever in some farming districts in Kenya. Investigations into outbreaks of the disease in the Lumbwa, Thomson's Falls–Gilgil, Nanyuki and Subukia districts revealed a state in which herds of grade cattle comprised animals reacting to an apparent mild form of East Coast fever. Blood smears from cattle on one farm gave a picture of blood cells and parasites similar to that seen in mild cases, produced in the laboratory, by batches of *R. appendiculatus* starved for 266 to 348 days. Some animals reported to have recovered from such a reaction were tested at the laboratory, and were found to be immune. Others with no record of having contracted the disease (but which were thought, by the farmer, to be immune) were also tested by infesting them with freshly moulted batches of infected ticks. These reacted, and the majority died of East Coast fever. Tests at the laboratory on cattle from another farm where the mortality was reported to be low gave results similar to those already

* The work described in this article was carried out when the author was Chief Field Zoologist to the Department of Veterinary Services, Kenya Colony.

described; some of the animals were susceptible; some were immune. Reports from still another farm, however, record that out of 40 animals sick with East Coast fever, 36 recovered.

Dipping Affects Tick Infectivity

The animals concerned in these outbreaks were adult cattle. They had been dipped at short intervals (5 to 7 days) for most of the year. During the wet weather, however, when tick activity tends to increase, it is customary to relax regular short-interval dipping and to discontinue hand-dressing.

The peculiar incidence of the disease may, therefore, be attributable to the effect of age (or starvation) on the parasite in ticks not destroyed by dipping; or, as Wilson's (1950) investigations in Uganda suggest, to the low infestation of pastures by infected ticks.

The experiments and observations recorded above—and those of Wilson—indicate that the continuation of regular dipping, or spraying, and hand-dressing at short intervals should be advantageous to the farmer at a relatively early stage. They encourage the belief that the disease could be controlled, and mortality could be reduced considerably, within a period of 12 months. In fact, some farmers have achieved this effective control. They have maintained freedom from disease by adopting additional measures against the introduction of East Coast fever in cattle brought on to the farm, and in ticks infecting such cattle. Infection in ticks which have not entirely disappeared from the land will have died out in about a year.

It is not likely that the time taken by engorged larvæ to moult to nymphæ, and for engorged nymphæ to moult to adults, will often materially affect the survival of the parasite in ticks in the endemic and potential East Coast fever areas of Kenya. In the lower, moist and warm districts (4,800 feet or less), engorged larvæ and nymphæ will moult in as short periods as 6 to 10 days and 8 to 14 days respectively; and in the higher, colder districts (from about 6,000 to 7,000 feet), the moulting periods may be extended to 28 to 40 days respectively. It is fairly certain, however, that in the period of 15 months for which farms in East Coast fever cleansing areas are normally quarantined when an outbreak of the disease occurs, the parasite in ticks on the farm will have died out—and the number of surviving ticks will have been depleted if dipping, or spraying, and hand-dressing are carried out with thoroughness.

The number of reactions followed by recovery, on the first infestation or on the second attempt, with batches of infected ticks kept unfed for 266 to 348 days (*see* Table I) suggested a phase of attrition in the virulence of *T. parva* which not only offers an explanation of the incidence of the disease on some farms, but also that it might be possible by experiment to determine a short period when infected ticks could be used to transmit, in a high percentage of cases, a mild form of East Coast fever, followed by recovery and subsequent immunity.

Numerous batches of infected adult ticks were kept unfed for 266 days. At short intervals thereafter, 1, 5, 10 or 50 ticks were put to feed on cattle which had been reared on farms or veterinary centres reputedly free of East Coast fever. The cattle were mature adults comprising grade and zebu oxen. Seven, used as controls, were infested with freshly moulted adult *R. appendiculatus*. These reacted and died. Later, ticks from the same batches as those used in the control, were fed on 43 oxen. Out of this lot of oxen, 25 animals (or 62.5 per cent) failed to react on the first infestation, but contracted a fatal form of the disease when again tested with freshly moulted infected ticks. Six of the animals (or 15 per cent) became sick on the first infestation and died of East Coast fever. Of the remainder, nine (or 22.5 per cent) contracted a mild form of the disease and subsequently proved to have acquired an immunity. Three of the oxen failed to react to repeated infestations with starved ticks and, later, with large numbers of young infected adults.

The nine mild reactions were provoked by infected ticks which had been starved for widely different periods within the range (82 days) of 266 and 348 days; and there was no indication of a shorter period for which the ticks could be starved and relied on to provoke a non-fatal reaction. The phase of attrition in the virulence of the parasite in ticks, if a definite phase exists, has not therefore been determined with that accuracy required to warrant attempts on a larger scale to immunize cattle by infestation with starved infected ticks.

Effect of Constant High Temperature

A study of East Coast fever outbreaks, over many years in Kenya, in relation to the distribution of the chief vector, *R. appendiculatus*,

pointed to conditions, other than the age of infected ticks, being concerned in the so-called peculiar incidence of the disease. In the sparsely covered hot, dry areas such as the Northern Frontier Province, and in the high cold areas above 7,000 feet, the common vector of *T. parva* is either absent or occurs in very restricted sheltered localities. There are, however, other species of ticks which are common and which have been proved, experimentally, to be capable of harbouring the parasite and of transmitting the disease to cattle. In other areas, as in the hot and humid coastal belt, *R. appendiculatus* exists plentifully in localities where the absence of tsetse flies permits of cattle farming, and in small numbers even in the fly-infested areas. The latter, and some of the up-country treeless plains, are considered to be the potential East Coast fever areas. Furthermore, *R. appendiculatus* occurs with other vectors (*R. neavei* and *R. simus*) in strips of country, varying in width, between the enzootic and endemic East Coast fever districts of the lower Highlands (4,800 feet or less) and the hot, dry "clean" districts. These are the "marginal" areas.

The incidence of the disease in many of these areas is sporadic and outbreaks are often short-lived even in the absence of tick control or mass movement of stock.

This picture, which it is hoped to describe in greater detail in the near future, bears a strong resemblance to that which has been drawn on the basis of the altitude and temperatures in various parts of the Colony (Lewis, 1939).

Preliminary observations on the effect of different temperatures on *T. parva* in its usual tick-vector were published in 1937 (Fotheringham and Lewis). It was explained that the parasite in infected nymphæ of *R. appendiculatus* is not destroyed, nor is development disturbed, when the unfed ticks are exposed continuously for 1, 2 and 3 weeks to temperatures of 4° to 6° C. (39.2° to 42.8° F.). Unfed nymphæ exposed to a temperature of 35° to 38° C. (95.0° to 100.4° F.) were either so weak as a result of this treatment that they were unable to feed well on cattle, or they failed to survive. It should have been explained that the engorged larvæ in these earlier experiments had been subjected to a relatively low temperature of 25° C. (77.0° F.) during the moulting phase, and that the resultant nymphæ perished as a result of an abrupt change to a higher temperature immediately after moulting. Other batches of engorged ticks were incubated at a high temperature immediately after repletion and during the whole moulting period. A high percentage of the resultant nymphal and adult ticks survived exposure to the same high temperatures, and fed readily on cattle, sheep and rabbits.

Larval-nymphal Moult

When batches of ticks fed as larvæ or as nymphæ on cattle reacting to East Coast fever were exposed as engorged ticks to temperatures of 35° to 38° C., the nymphæ and adults respectively which emerged from the moult failed repeatedly to transmit the disease to susceptible cattle although many ticks fed well. These results were surprising as no record could be found or obtained, in literature or by reference to scientific colleagues, of the complete disappearance, or loss of virulence, of a protozoan parasite in its invertebrate host by exposure of the latter to a high temperature for a relatively short period of days. It seemed possible also that exposure of infected ticks to slightly lower temperatures might so reduce the virulence of *T. parva*, instead of destroying it, that the disease provoked by the exposed vectors would produce a reaction with recovery, and subsequent immunity.

Large numbers of clean larvæ of *R. appendiculatus* were put to feed on cattle in the final stages of a fatal reaction to East Coast fever. Immediately after dropping off as replete, separate batches of gorged larvæ were incubated at temperatures of 31° C. to 33° C., 34° C. to 35° C. and at 35° C. to 36° C. Sometimes the treated batches were exposed at these temperatures for additional short periods after moulting. Usually, however, the ticks were transferred to room temperature (19° to 22° C.) as soon as moulting was complete. The first and the last lot of larvæ to drop engorged were incubated at 25° to 26° C. (77° to 78.8° F.), and the resultant nymphæ were used as controls.

The nymphæ emerging from the moult were fed on grade cattle, on pure native (zebu) cattle, and on Sahiwal-Zebu crosses reared on farms or at veterinary centres reputed to be free from East Coast fever.

The results of infesting the cattle with these nymphæ, incubated at high temperatures during the full larva-nympha moult, are summarized in Tables II, III, IV and V. The figures in columns 1 and 6 represent the day on which the earliest moulting was observed. Successful

transmission followed by death of the infested bovine is represented by "+d", a reaction and recovery by "+R", and no reaction by a minus (−) sign.

The outstanding feature in the above tables is the loss of infectibility in the nymphæ which were exposed to a temperature of 35° to 36° C. during the whole larva-nympha moult. Some batches lost the infection at 34° to 35° C., and a few at 31° to 33° C.; but none lost the ability to infect susceptible cattle after having been incubated at the control temperature.

It will be noted that the number of days of exposure at high temperature, which was also the time taken for the complete moult and for the development of the parasite in the ticks, was often as low as 5 to 6 days.

All but one of the cattle were susceptible to East Coast fever; and there was apparently no difference in susceptibility between any one group or type of animal and another. All were adult cattle. A number of cattle recovered from a reaction either on the first infestation or on subsequent testing. The number of recoveries in Tables III and IV may, or may not, be significant.

Nymphal-adult Moult

A similar series of experiments was carried out with infected adult *R. appendiculatus* which had been exposed to the same high temperatures for the full moult from engorged nymphæ to adults. The results were similar for all groups exposed up to 34° to 35° C. except that the number of cattle which failed to react to infestation by incubated ticks was less. Batches of adult ticks derived from replete nymphæ incubated at 35° to 36° C. transmitted a fatal East Coast fever to the eight cattle infested (Table VI). The development of the parasite, and its virulence, was not, in this case, affected by a temperature which, in the larva to nympha moult, rendered the batches of resultant nymphæ innocuous to susceptible cattle.

A slight rise of temperature, however, did affect the parasite. In fact, gorged nymphæ exposed to 37° to 38° C. produced adults in which the loss of infectibility was almost complete as is shown in Table VII.

Three batches retained viable parasites. Two of these induced mild reactions followed by recovery, and one batch transmitted a fatal East Coast fever.

The temperatures at ground level, in tufts of grass, under the soil surface, and in cracks and crevices—the hiding places of engorged ticks—have been taken in a few districts where tick-vectors of East Coast fever exist, and a number of observations have been made to ascertain the range of temperature to which infected and replete ticks are exposed in different seasons of the year. A set of observations in the coastal belt of Kenya over a period of 11 days in October, 1949—a hot and dry period—gave a daily range about 25° to 50° C. on the surface in a sparsely grassed site exposed to sunlight, a range of 25° to 45° C. at one inch under ground level in the same site, and from 20° to 30° C. in the shade of a large tree. The soil temperature at Kabete (6,209 feet) in the warm, dry weather varied diurnally on an average from 17.5° to 26.0° C.

Effect of Varying Temperatures

The effect of change of temperatures on the parasite in infected replete ticks was therefore tested. Larvæ and nymphæ were fed on an East Coast fever reactor and divided into lots of 200 engorged larvæ and of 100 engorged nymphæ. Some lots were incubated, in the first instance, for three and four consecutive days at the appropriate high temperatures found earlier to be lethal to the parasite. They were then transferred to an incubator in which the temperature was maintained at 22° C. where they were allowed to complete the moult. Other lots were first exposed, after repletion, to 22° C. for three and four days; and then incubated at the higher temperatures until all the ticks had moulted.

The treated ticks were fed, as nymphæ and adults respectively, on mature cattle, and on a few calves. Reactions were set up in four out of five cattle tested with ticks exposed to a temperature of 35° to 36° C. in the second half of the moult. One was immune; one reacted and recovered, and three died of the disease. Five adult cattle were also used for feeding ticks which had been incubated at the high temperature for the first half of the month. Three of these cattle reacted and died of East Coast fever. Two, infested with 86 or more nymphæ, recovered (Fig. I).

In view of these results, experiments on the effect of fluctuating temperatures have not been continued.

The history of the calves infested with ticks which had been exposed in the second half of the moulting phase is of interest. Five were infested with no less than 120 nymphæ. None of the beasts was over three months old.

One control, on which were fed untreated ticks, died of typical East Coast fever. One infested with the nymphæ, incubated as replete larvæ at 35° to 36° C. for three days showed a rise of temperature (Fig. 2) 21 days after attachment of ticks. No lymphatic gland was visibly swollen until that time had elapsed. Koch's bodies in gland smears were common on the 21st day and were likely to have been present in the gland before that day. Small piroplasms were rare in blood smears up to the day of death when they were common. Koch's bodies also appeared in the blood; and were abundant in spleen smears taken after death.

The reaction in another calf infested with 140 treated ticks was very much the same except that the animal recovered (Fig. 3). The incubation period continued for 21 days instead of the usual period of about 9 to 13 days. Koch's bodies were rare in gland smears, and piroplasms were seen in blood examinations. The remainder of the calves reacted normally and died.

Number of Infecting Adult Ticks

Another aspect of the problem relating to East Coast fever was raised by Lowe (1932). It was suggested that a calf mortality of about 60 to 70 per cent due to East Coast fever was in direct ratio to the degree of tick infestation, and that by weekly dipping without hand-dressing this infestation is inhibited so that in an enzootic area, the calves become mildly infected by the few ticks which persist in the ears and around the anus, and immunity is attended with a loss of possibly 5 to 10 per cent.

Lewis and Fotheringham (1941) studied this aspect in regard to adult cattle and came to the conclusion as did Lounsbury (1903), Theiler (1904) and Walker (1927)—that death in adult cattle at any rate usually followed whether the number of ticks fed on the beast was large or small.

Experiments carried out by Wilson (1949) at Entebbe in Uganda showed that in young calves a reduction in the number of infected ticks engorging appeared to favour the development of a mild non-fatal type of *T. parva* infection. He controlled the number of ticks in a paddock by spraying the young animals —and reduced infection by the introduction of a few immune beasts—where infected nymphæ and adults were reported to occur. In his laboratory experiments Wilson found that one or two nymphæ from a freshly moulted infected batch often failed to provoke a reaction whereas three or more produced an acute form of East Coast fever, and death.

Field experience in Kenya indicates that while the mortality from East Coast fever among calves varies considerably, the disease in adult cattle is usually, but not invariably, fatal. Recoveries among adults are not rare; and there is sometimes an apparent connexion between the virulence or mildness of the disease and the tick population. On the other hand, numerous instances could be given of fatal cases of East Coast fever on farms where one or two adult cattle—sometimes a valuable bull or cow—have contracted the disease when *R. appendiculatus* has been extremely difficult to find.

Earlier observations made at Kabete on fatal reactions to East Coast fever produced by one or two ticks have borne out the field experience, and it was considered unnecessary to report more than the conclusions of experimental confirmation (Lewis and Fotheringham, 1941). It is now considered desirable to publish these records together with additional data in order to clarify the position in this respect.

One Infected Adult Tick on Mature Cattle

In Table VIII is summarized the results of feeding one infected adult *R. appendiculatus* on adult grade and zebu cattle. The ticks, bred in the laboratory, are reared under conditions most favourable to their survival. They are kept at a temperature (19° to 22° or 25° C.) and humidity (60 per cent or more relative humidity) which have proved to be optimal for the ticks and for the parasites with which the ticks have been infected. Furthermore, the ticks were, in these series of experiments, never more than 100 days old.

It will be noted that a small number of clean ticks was put with the single infected ticks. This technique was adopted in order to ensure that the infected male or female fed to repletion. The development of the disease (incubation) and the reaction induced in mature cattle by one infected adult tick are similar to those induced by several or many adult *R. appendiculatus*. Of the three zebu (indigenous) cattle which failed to react at first, two were found to be immune to subsequent heavy infestations by infected batches of ticks, and one contracted the disease and died. It is not assumed that the zebu animals were more resistant to East Coast fever than the grade cattle, because no assurance can be given that

cattle purchased from the field have not previously contracted, and recovered from, a more or less mild attack of the disease.

One Infected Adult Tick on Calves

In the case of calves or young animals purchased from out-stations or reared at a laboratory or institution where tick control is normally and regularly practised, and the temperatures of the animals are taken daily, the full susceptibility of the beasts can usually (though not invariably) be relied on. Table IX shows the result of infesting calves with one adult *R. appendiculatus* from infected batches of ticks. All the calves were less than three months old at the time of infestation, and several were less than a month old. All the animals reacted to East Coast fever; the incubation period of the disease was within the normal limits (6 to 25 days) and the duration of the disease was not unusual. The vast majority of the 24 calves tested died of East Coast fever. The number of reactions and deaths among the grade and zebu calves was not significantly different.

The onset of thermal reaction was ill-defined in a few of these calves; and the parasites often appeared for only a short time—for two or three days—before death. In some cases, piroplasms and Koch's blue bodies were numerous throughout the reaction; in others, they became common, or appeared only a few hours before the animals died. The blood and gland pictures varied considerably.

It is evident from these results that even one infected adult of *R. appendiculatus* can transmit a fatal East Coast fever to susceptible adult cattle and to calves; and that non-fatal reactions cannot be attributed merely to low numbers of ticks comprising nymphæ and adults.

It is generally recognized that calves and immature cattle under natural conditions possess a greater degree of resistance to East Coast fever than mature, adult cattle. The effect of infestation recorded in Table IX might have been different if the young calves had been suckling their dams instead of being hand-fed, as they were; or had they been fed with an ample supply of milk. This lack of natural food may well have reduced the resistance to the infection, and contributed to the high mortality; but it could not have affected the transmissibility by the tick.

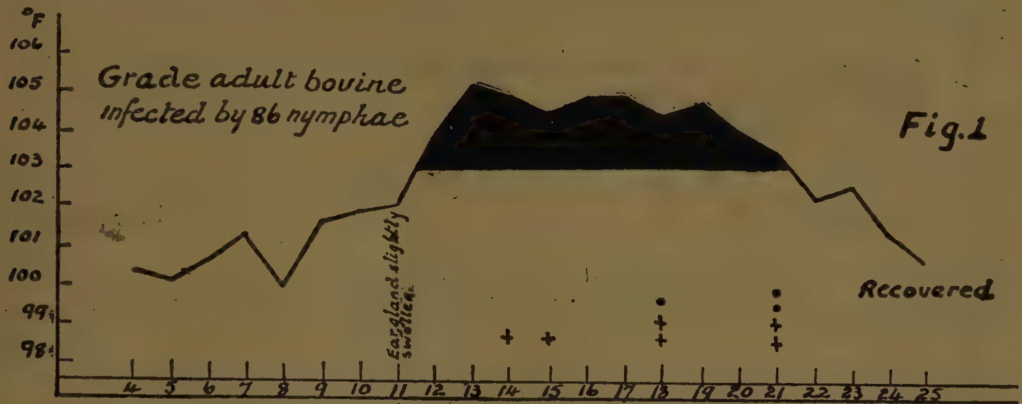
Low mortality among calves and young animals sometimes coincides with a low tick population. It occurs also where the tick infestation is heavy or moderately so; and, on occasions which appear to be rare, a high percentage of recoveries is recorded amongst adult cattle. The reactions in these cases present a very wide range of variation, particularly among calves; and the incubation of the disease may be prolonged. Recovery from one attack of the disease is sometimes (and perhaps more frequently than actually observed and recorded) followed by a second reaction which may be mild or severe (*see* Figs. 3, 4 and 5) as the early research workers, followed more recently by Piercy (1947) and Wilson (1950 and 1950a), have recorded.

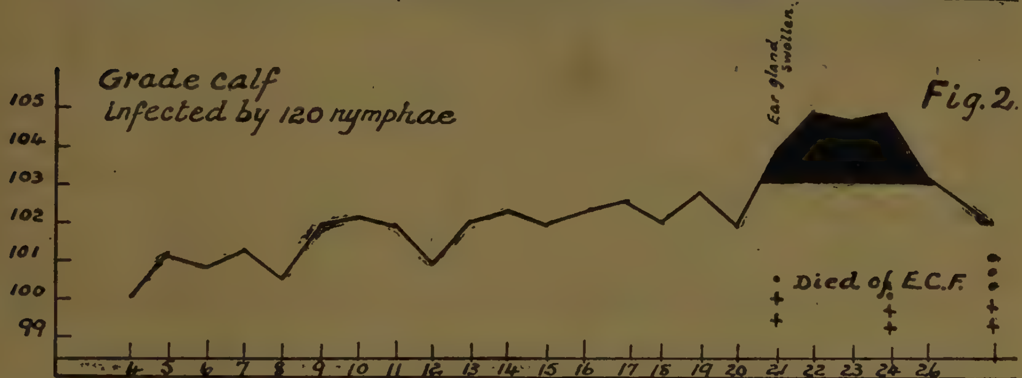
It may be of interest to note also the experience of a farmer who maintained a large number of indigenous cattle in a heavily tick-infested locality of Muhoroni (4,250 feet) in the Nyanza Province of Kenya. The European owner pointed out to the author a number of cows whose calves, like others contracted East Coast fever at a young age. The progeny of these particular cows, however, invariably recovered from the disease. An examination of the farmer's record confirmed his statements and it seemed as if resistance to East Coast fever is inherent in some families of cattle. No dipping was practised on this farm; and *R. appendiculatus* was abundant.

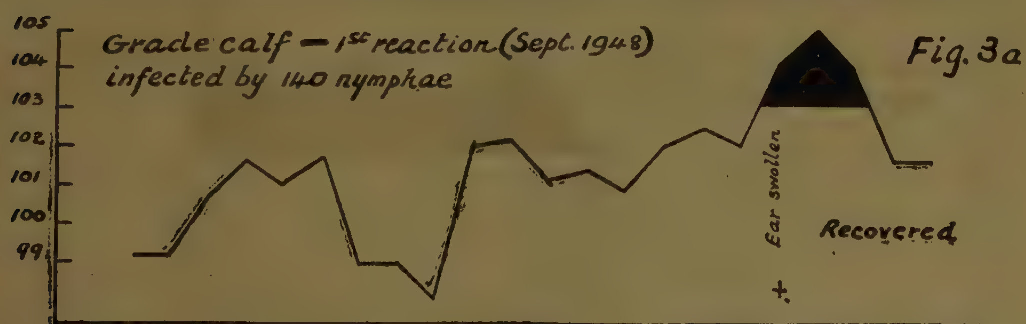
Number of Infecting Nymphal Ticks

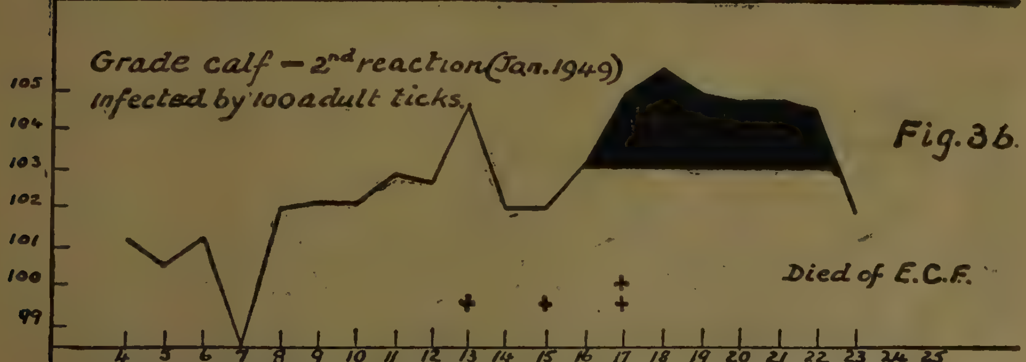
Experiments with nymphal ticks at the Veterinary Research Laboratory, Kabete, have not yet included a series of transmissions by very small numbers (one or two) of nymphæ infected as larvæ. Preliminary tests, carried out a number of years ago with the view of planning a comprehensive series of experiments, contained a few cases of adult cattle which reacted to infection by a single nympha (Fig. 6), by three or more nymphæ (*see* Table I and Figs. 12 to 15 in Lewis and Fotheringham, 1941), and by more than 100 nymphæ on rare occasions. Adult cattle were used at this stage in preference to calves which, due to their reputed resistance under natural conditions, might lead to confusion in the interpretation of transmissibility by the ticks.

Failures to transmit East Coast fever to susceptible adult cattle have been experienced a few times when as many as 20 to 86 nymphæ from infected batches were fed within three or four months of moulting. Some animals reacted after a prolonged incubation period and died whereas a few reacted typically but recovered. Usually, however, cattle infested with five or more infected nymphæ contracted a normal, fatal form of East Coast fever. Failures also occurred, more infrequently, with small

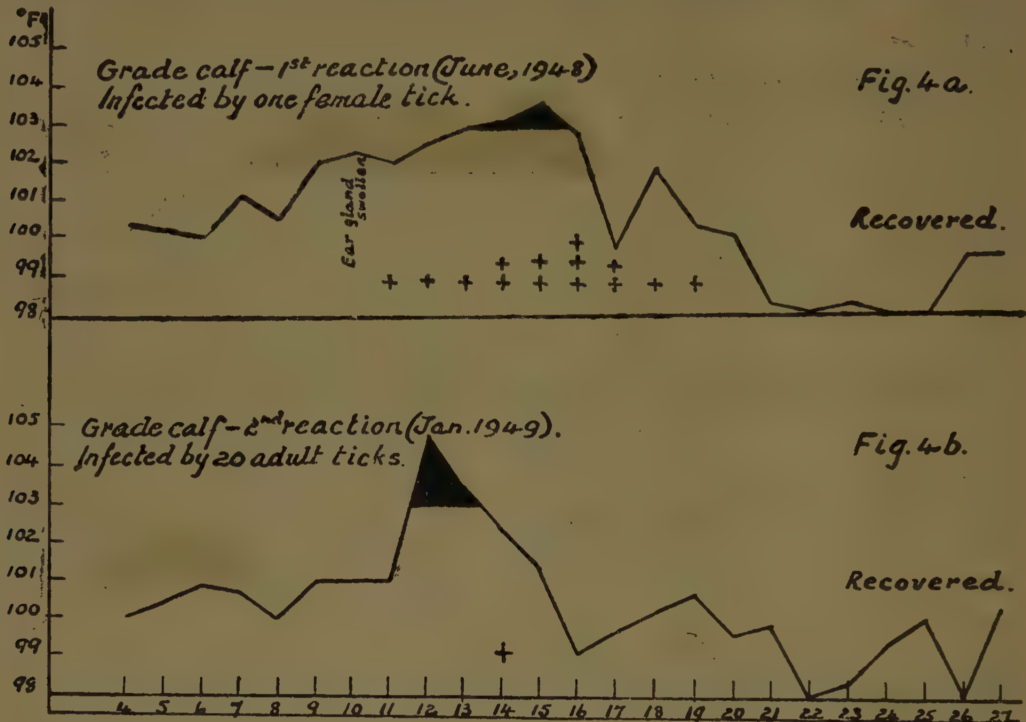


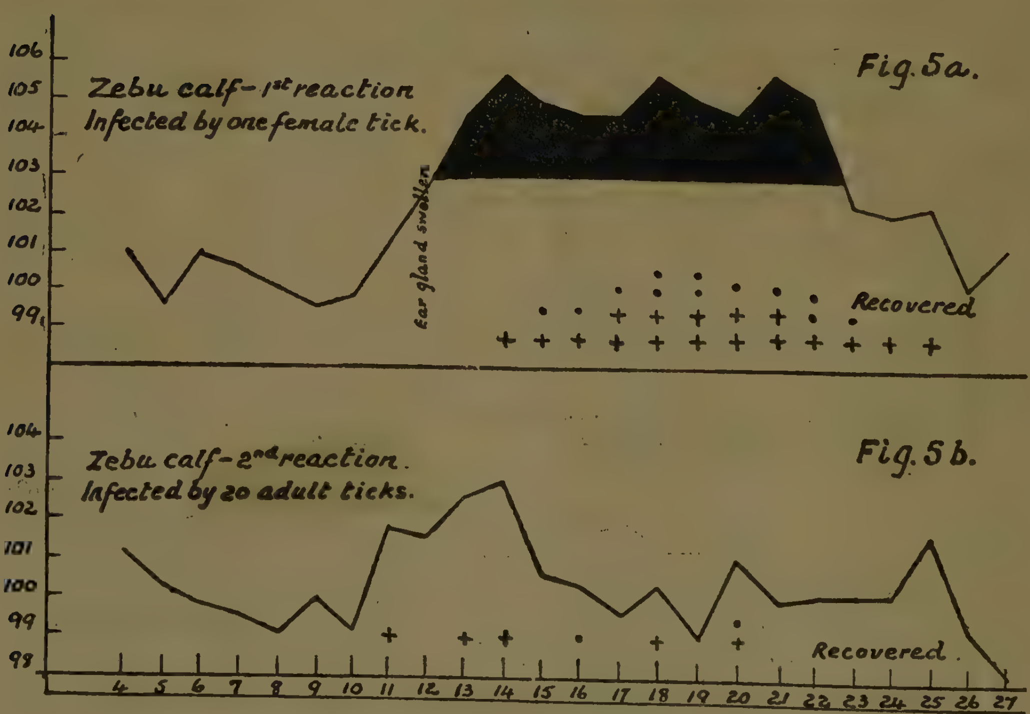




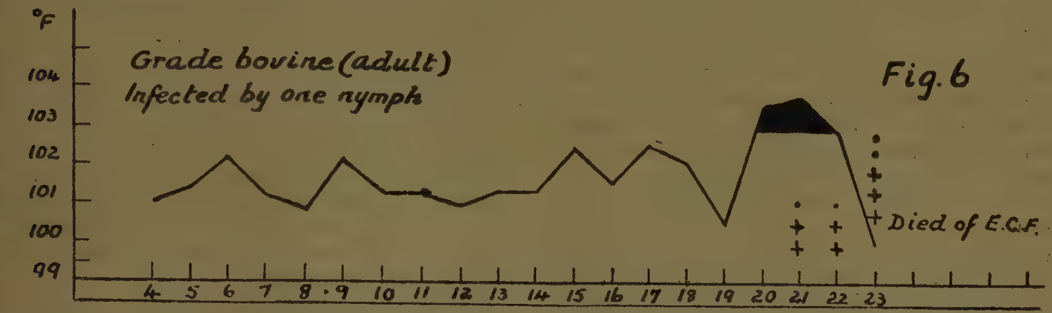


Figures on base lines represent number of days after infestation.
+ = Koch's bodies; • = small piroplasms of E.C.F.





Figures on base lines represent number of days after infestation.
+ = Kochs bodies; • = small piroplasms of E.C.F.



numbers (one, or two) of newly moulted adults; and recoveries following infestation by a few and by many adult ticks have been recorded (Lewis and Fotheringham, 1941). Theiler (1904a), too, refers to his experiments where "Out of nine oxen which were infected with pathogenic brown ticks, eight died of East Coast fever. The experiments prove that two adults are able to produce the disease. But experiment Ox. No. 200, proves that two ticks (one male and one female) are not always able to produce the disease". Later, in the same report, he states "with regard to the quantity of ticks required, my experiments show that two ticks are quite sufficient to cause the malady to appear in the typical period. Probably, one infected tick would be able to do the same. Therefore, not many ticks are required to infect a farm". Lounsbury (1904) writes of a similar experience: "An old cow was infested with a lone female [tick], and in due time it fevered. At the same hour, a two-year-old heifer was infested with two specimens, one a male and the other a female, and almost on the same day as the other this beast sickened. The cow is recovering, but the heifer has succumbed."

The results at Kabete so far confirm these findings, and support Theiler's (1904a) conclusion that *R. appendiculatus* must be considered as the principal carrier of East Coast fever while the adult ticks which have been feeding as nymphæ on sick cattle must be considered as the main intermediate host; that is, nymphæ are less efficient as carriers of *T. parva*. This is borne out to some extent by Cowdry and Ham (1932), who, by examining ticks which had been fed on cattle reacting to East Coast fever, found 60.1 per cent of 290 adult ticks, and from 30 to 40 per cent of the nymphæ with *T. parva* in the salivary glands. The ticks which in this case were first kept at 14° to 17° C. (57° to 62° F.) were transferred to an incubator and maintained at 28° C. (82.4° F.) in order to speed-up the moult. This change-over during the moult may have had a significant effect on the ultimate infection rate in the moulted ticks. Nevertheless, it seems that *T. parva* develops less readily during the larvæ-nymphæ moult than in the nymphæ-adult phase. It is evident that the parasite is more sensitive to high temperatures during the former.

Conclusions

The relationship of *T. parva* and its tick host is not as close and continuous as, for instance, that which exists between the causal organisms of heartwater, Nairobi sheep disease, redwater, and their tick vectors. *T. parva* is not passed from the infected female tick through the eggs and on to the larvæ; and the parasite disappears if infected ticks feed on immune cattle or on any animal not susceptible to East Coast fever, or, in other words, the ticks clean themselves of the infection. It has been shown also that the parasite perishes in adult nymphæ and adult *R. appendiculatus* which, after moulting from replete larvæ and nymphæ respectively, have had no opportunity of obtaining a meal off a bovine host for about a year. Exposure to continuous high temperatures for the full, but short, period of moulting the parasite in ticks loses its virulence, or is destroyed. The infection rate of nymphal *R. appendiculatus* which have fed, in the larval instar, on a diseased animal seems to be lower than in adult ticks infected in the preceding nymphal instar.

This discontinuous infection and gradual loss of virulence not only explains, in part at least, the natural limitations and peculiar incidence of East Coast fever reported from areas where measures of tick control are practised irregularly and where conditions not optimal for the vector, but it also indicated the early advantages that can be gained by supplementing the natural process by artificial measures to protect stock, and especially cattle from tick infestation.

Dipping or spraying and hand-dressing with an effective acaricide in certain seasons not

only will, in time, keep down or even slowly reduce the tick population and its infection rate. It will lessen the death role from East Coast fever, and may increase the number of recoveries from this disease. On the other hand, periodical suspension of these measures will enable a residual tick population to survive, provide a recurrent source of infection often inapparent in cases of mild reactions and re-infections. Persistent dipping or spraying and hand-dressing for at least 12 months in most areas of Kenya should eradicate the disease especially if additional precautions are taken to prevent its re-introduction.

It will be appreciated that mild reactors to East Coast fever (Lewis and Fotheringham, 1941) and animals which contract the disease a second time provide a source of infection to larval and nymphal ticks which can, subsequently, transmit a virulent disease to susceptible cattle, and that even one infected adult *R. appendiculatus* can provoke a fatal attack of East Coast fever.

The fate of *T. parva* in the vertebrate host (cattle and some species of game) is a subject which has not yet been investigated fully. The apparent resistance of calves in particular, the loss of immunity after recovery from a first attack in some cases, and the occurrence of "muthioko" (turning sickness) with its cerebral hæmorrhages, containing Koch's blue bodies indistinguishable from those of East Coast fever and related diseases, are subjects for further investigation.

No curative drug is yet available for East Coast fever. The only practical alternative at hand is the use of acaricides against tick infestation in the enzootic and the sporadic areas as well as their early introduction, as dips or sprays into those areas which are unoccupied or reclaimed from tsetse flies and which are potentially suitable to the vectors and to the widespread increase of the parasite.

ACKNOWLEDGMENT

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TABLE I

Age of Tick	No. of Ticks Fed	Phase of Tick	Result on Bovine	Result of Test on Bovine	Age of Tick	No. of Ticks Fed	Phase of Tick	Result on Bovine	Result of Test on Bovine
(*Days*)					(*Days*)				
200	11	A	d	—	327	53	N	—	R
202	46	N	d	—	328	30	N	—	d
233	58	N	d	—	330	45	N	—	d
247	1	A	d	—	335	18	N	—	R
254	23	N	d	—	335	34	N	—	R
263	49	N	d	—	337	60	A	R	—
265	77	A	d	—	338	58	A	R	—
266	83	A	d	—	343	9	N	R	—
266	19	N	—	R	344	24	N	—	R
279	30	A	—	d	345	30	A	—	d
284	62	A	d	—	348	20	N	d	—
291	27	N	—	d	354	29	A	—	d
293	40	A	d	—	358	31	A	—	d
303	28	N	—	d	370	77	N	—	d
322	33	N	R	Immune	392	6	N	—	R
327	46	N	—	d	415	37	N	—	d

Table 1.—A=adult ticks. N=nymphal ticks.
d=indicates death of bovine following infection with East Coast fever.
R=indicates recovery after a reaction; and a dash denotes no reaction.

TABLE II

Controls: Infected, replete larvæ incubated at 25° to 26° C. and fed, as nymphæ, on an equal number of grade and of zebu cattle:—

Larvæ Moulted to Nymphæ (*in days*)	No. of Nymphæ put on Bovine	No. of Nymphæ Fed to Repletion	Result on Bovine	Result of Test on Bovine	Larvæ Moulted to Nymphæ (*in days*)	No. of Nymphæ put on Bovine	No. of Nymphæ Fed to Repletion	Result on Bovine	Result of Test on Bovine
9	20	19	+d	—	9	69	26	+d	—
9	20	20	+d	—	10	69	24	+d	—
8	80	13	+d	—	10	20	20	+d	—
14	80	17	+R	—	10	20	17	+d	—
10	20	20	+d	—	9	80	19	+d	—
8	20	18	+d	—	8	80	12	+R	Immune
9	20	18	+d	—	9	20	16	+d	—
9	20	14	+d	—	9	20	12	+d	—
9	20	11	+d	—	9	50	29	+d	—
9	22	22	+d	—	8	50	36	+d	—

TABLE III

Exposed ticks: Infected, replete larvæ incubated at 31° to 33° C. and fed, as nymphæ, on grade and on zebu cattle:—

Larvæ Moulted to Nymphæ (*in days*)	No. of Nymphæ put on Bovine	No. of Nymphæ Fed to Repletion	Result on Bovine	Result of Test on Bovine	Larvæ Moulted to Nymphæ (*in days*)	No. of Nymphæ put on Bovine	No. of Nymphæ Fed to Repletion	Result on Bovine	Result of Test on Bovine
7	20	19	R	Immune	6	20	10	d	—
7	20	20	d	—	6	20	16	R	Immune
7	20	20	—	d	6	20	17	d	—
7	20	18	R	Immune	6	20	18	R	Immune
7	20	20	—	d	7	20	19	—	d
7	20	18	—	d	7	20	20	—	d
7	20	19	d	—	6	269	149	d	—
7	144	79	d	—	6	268	42	R	Immune
7	145	52	d	Immune	7	83	26	d	—

TABLE IV

Exposed ticks: Infected, replete larvæ incubated at 34° to 35° C. and fed, as nymphæ, on native cattle:—

Larvæ Moulted to Nymphæ (*in days*)	No. of Nymphæ put on Bovine	No. of Nymphæ Fed to Repletion	Result on Bovine	Result of Test on Bovine	Larvæ Moulted to Nymphæ (*in days*)	No. of Nymphæ put on Bovine	No. of Nymphæ Fed to Repletion	Result on Bovine	Result of Test on Bovine
6	170	69	d	—	6	200	60	—	d
6	174	83	—	d	6	140	69	R	Immune
6	175	104	—	d	6	157	134	—	d
6	177	85	—	R	6	177	79	—	d
6	165	94	R	Immune	6	130	111	d	—
6	192	95	d	—	6	189	87	—	d

TABLE V

Exposed ticks: Infected, replete larvæ incubated at 35° to 36° C. and fed, as nymphæ, on grade zebu, and Sahiwal-zebu cross cattle:—

Larvæ Moulted to Nymphæ (in days)	No. of Nymphæ put on Bovine	No. of Nymphæ Fed to Repletion	Result on Bovine	Result of Test on Bovine	Larvæ Moulted to Nymphæ (in days)	No. of Nymphæ put on Bovine	No. of Nymphæ Fed to Repletion	Result on Bovine	Result of Test on Bovine
6	170	53	—	d	5	168	82	—	d
6	195	39	—	d	5	179	78	—	d
6	144	43	—	d	5	103	59	—	d
6	92	64	—	d	5	117	88	—	d
6	92	53	—	d	6	178	66	—	d
6	92	50	—	d	7	58	29	—	R
6	92	61	—	d	6	145	44	—	Immune
6	154	51	—	R	7	161	51	—	d

TABLE VI

Exposed ticks: Infected, replete nymphæ incubated at 35° to 36° C. and fed, as adults, on grade and on zebu cattle:—

Nymphæ Moulted to Adults (in days)	No. of Adults put on Bovine	No. of Adults fed to Repletion	Result on Bovine	Nymphæ Moulted to Adults (in days)	No. of Adults put on Bovine	No. of Adults Fed to Repletion	Result on Bovine
11	33	29	+d	10	94	77	+d
10	81	66	+d	10	70	54	+d
11	77	66	+d	10	56	43	+d
10	58	47	+d	9	61	53	+d

TABLE VII

Exposed ticks: Infected, replete nymphæ incubated at 37° to 38° C. and fed, as adults, on zebu cattle:—

Nymphæ Moulted to Adults (in days)	No. of Adults put on Bovine	No. of Adults Fed to Repletion	Result on Bovine	Result of Test on Bovine	Nymphæ Moulted to Adults (in days)	No. of Adults put on Bovine	No. of Adults Fed to Repletion	Result on Bovine	Result of Test on Bovine
8	50	47	—	+d	8	48	22	—	+d
9	49	44	—	+d	9	51	44	—	+d
9	51	47	—	+d	8	55	54	—	+d
8	54	46	—	+d	8	56	48	—	+d
8	54	46	—	+R	8	42	42	—	Immune
8	42	38	+R	—	9	76	73	—	+d
9	39	33	+d	—	9	38	33	—	+d
9	41	35	—	+d	9	50	35	+R	—

TABLE VIII

MATURE CATTLE INFESTED WITH ONE INFECTED ADULT TICK

ANIMAL	TICKS PUT ON BOVINE		INCUBATION (E.C.F.)	REACTION	RESULT	Breed of Animal
Bovine No.	Infected	Clean	Period	Period		
			(in days)	(Days)		
X559*	1 female	2 males	—	—	—	Zebu
X995	,,	4 ,,	16	10	d	Grade
X1228†	,,	2 ,,	—	—	—	Zebu
X2353	1 male	2 females	15	13	d	,,
X4550	,,	1 female	20‡	3	d	Grade
X4640	1 female	1 male	12	6	d	,,
X4937	,,	,,	16	6	d	,,
X4939	1 male	1 female	22‡	10	R	,,
X4587	,,	3 females	13	15	d	,,
X4611	1 female	3 males	13	12	d	,,
X6443	1 male	3 females	—	—	—	Zebu
X6444	1 female	3 males	13	7	R	,,
X6445	1 male	3 females	9	18	d	,,
X6446	1 female	3 males	15	21	d	,,
X6447	,,	,,	13	10	d	,,
X6448	1 male	3 females	12	19	R	,,
X6449	1 female	3 males	12	20	d	,,

*Bovine No. 559 proved to be immune to subsequent infestation with numerous infected adult ticks.

†Bovine No. 1228 later reacted to infestation by many infected nymphæ.

‡Note prolonged incubation period.

TABLE IX

GRADE AND ZEBU CALVES INFESTED WITH ONE INFECTED ADULT TICK

ANIMAL	TICKS PUT ON BOVINE		INCUBATION (E.C.F.)	REACTION	RESULT	Type of Bovine
Calf No.	Infected	Clean	Period	Period		
			(in days)	(in days)		
4587	1 male	3 females	13	15	+d	Grade
4611	1 female	3 males	13	11	+d	,,
4612	,,	,,	12	11	+d	,,
5374	,,	,,	13	10	+d	,,
5376	,,	,,	11	6	+R	,,
5426	,,	,,	8	8	+d	,,
5567	,,	,,	9	17	+d	,,
5568	,,	,,	10	11	+d	,,
5645	1 male	1 female	13	8	+d	,,
5646	,,	,,	14	11	+d	,,
5647	,,	,,	9	14	+d	,,
5638	1 female	3 males	10	8	+d	,,
5684	,,	,,	9	12	+d	,,
5685	,,	,,	13	6	+d	,,
5942	1 male	1 female	14	4	+d	Zebu
5493	1 female	1 male	11	11	+d	,,
5944	,,	,,	11	6	+d	,,
5971	1 male	1 female	22*	19	+d	,,
5974	,,	,,	14	16	+d	,,
6026	1 female	1 male	16	9	+d	,,
6034	1 male	2 females	13	11	+d	,,
6205	,,	,,	15	8	+d	Grade
6233	1 female	2 males	12	10	+R	Zebu
6234	,,	,,	12	11	+d	,,

*Note prolonged incubation.

SMALL EARTH DAMS FOR THE IRRIGATION OF RICE FIELDS

By Murray Lunan, Agricultural Officer, Tanganyika

(*Received for publication on 1st August, 1950*)

R. B. Allnutt [1] has described in this Journal how the people in Shinyanga, in very unfavourable circumstances, succeed in producing a crop of paddy in most years by careful bunding to collect all possible rainfall, run-off or seepage. He has also mentioned briefly that sometimes the water collected in training-bunds or in cattle-ponds is used to augment the natural supplies of water.

In Unyamwezi, the eastern half of the Western Province of Tanganyika, similar conditions exist and rice-growing is a gamble except in the few favoured valleys with sufficient seepage, or unless special precautions are taken to conserve the available water.

The rainfall during the growing season (November to May) is rarely inadequate in total amount, but the precipitation is very erratic and there are often long dry spells which are disastrous to the crop. Most harmful of all is the usual spell of dry weather which may last for several weeks any time from January to March. Unless this and other dry spells can be tided over by the use of irrigation water, rice-growing in Unyamwezi must remain a gamble with the dice loaded against the grower. The limiting factor to rice production is undoubtedly this erratic supply of water, as there is ample soil suitable for rice, diseases are of little importance, and birds and vermin, though a nuisance, can be kept away.

There are two small experimental stations in Unyamwezi, Tumbi and Mwanhala. At each of these, rice is grown in bunded fields which can be irrigated from small earth-walled dams during periods in the growing season when natural water is inadequate. During heavy rains, the dams fill up and the water is drawn off by gravitational flow when required for irrigation, several times during the growing season. The dam water may also be used to irrigate the seedbeds before transplanting, or to keep the paddy going if the rains stop early.

The yield of paddy from the experimental farms is estimated to be at least twice the district average over the course of years. This is not entirely due to the use of part-time irrigation, for better cultivation methods such as early transplanting, well-made level paddy-fields, close spacing, selection of seed, and the use of black ant-hill as manure, all play their part in producing better yields than in native practice. However, the provision of a constant sufficient water supply is by far the most important single factor in producing good paddy crops in Unyamwezi. In a very good season, the dams can be of little benefit, but such seasons are rare. In an exceptionally poor season, when the dams do not fill, they are useless. But, four years out of five, they can be of some benefit and sometimes mean the difference between a fair crop and no crop at all.

The improvement in yields due to part-time irrigation can more definitely be shown by experiments at Tumbi. The results are as follows, in kilos of paddy per acre:—

	1941/2	1942/3	1943/4	1944/5	1945/6
Part-time irrigation	952·2	1,067·1	644·3	832·9	404·2
No irrigation	1,015·2	874·1	140·8	908·1	127·2
Season's rainfall ..	48·36″	35·58″	34·43″	44·77″	30·12″

Rainfall average for ten years, 36·59″.

There is an overall increase of yield of 27 per cent due to part-time irrigation, and in the two poor seasons 1943-4 and 1945-6 the increases were 357 per cent and 217 per cent respectively.

In 1946, a scheme was put forward by the Senior Agricultural Officer in the Western Province for the construction of dams, similar to those at Tumbi and Mwanhala, throughout the Province. Money was provided from Development Funds and over 30 dams have been built since then, mostly in Unyamwezi. With other officers of the Agricultural Department, I have been associated with this work from the beginning and it may be useful if I give a brief description of how these dams were made, so that our early mistakes can be avoided and our experience passed on.

Useful information on the general principles of small earth dam construction was found in (*a*) "Field Engineering", F. Longland, Government Printer, Dar es Salaam; (*b*) "Small Reservoirs in Uganda", C. B. Bisset, Government Printer, Entebbe; and (*c*) "A Practical Handbook of Water Supply", F. Dixey, Burby, London. These general principles were modified to the peculiar needs of dams for irrigating rice-land, and to suit local conditions.

Owing to the extreme shortage of European staff, the work of siting, laying out and supervision of the construction of the dams became one of the many duties of the district agricultural officer, and methods had to be evolved whereby dams could be made with the very minimum of European supervision sometimes amounting to no more than ten hours per dam. This inevitably led to slower work and heavier labour costs than if constant supervision had been available, but, on the whole, results were fairly good and the cost of dams reasonable.

The Siting of the Dam.

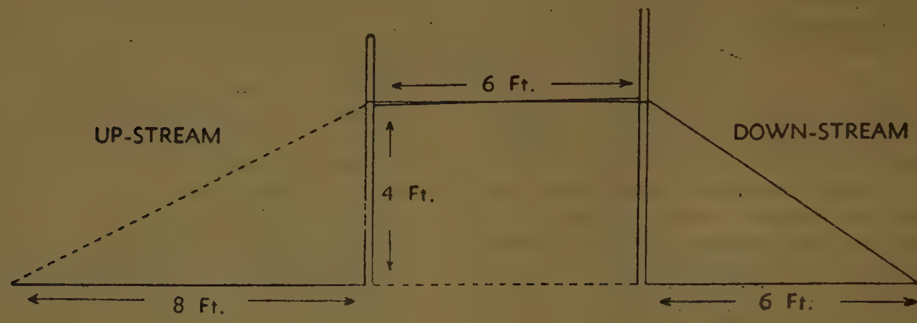
The choosing of the site is most important, and on it depends to a great extent the success or failure of the dam. The ideal dam site usually lies near the upper end of a valley where there is command of gently sloping ground and where the minimum sized bank can impound the maximum quantity of water and spillways can be cut into the sides of the valley. Less suitable sites can be found in side valleys, or on even slopes where the dam must be in the form of a horseshoe, and inlet ditches must usually be made. There is no point in selecting a site where there is already a stream or ample seepage water for rice-growing, or one where the land is not suitable for rice. Fortunately, in the rolling country of Unyamwezi the finding of possible sites was not difficult, and it was found that the most time-saving method was to set the local agricultural instructor to select a number of sites, from which the officer could later choose the best. Ideally, in order to make the best use of these rice dams, it is necessary to make a detailed survey of the catchment area and the area to be irrigated, to estimate the run-off and the probable amount of water which could be impounded. Unfortunately, with the available staff, and the available geological and meteorological data, this was not possible, but, with experience, the officer could judge reasonably well what was a good site. It is necessary to choose a place where the soil in the valley bottom is fairly impervious and where it is suitable for wall-building, as in such small dams it is not economic either to do much puddling or to carry soil far for the construction of the wall. The dam should be close above the area to be irrigated, and should not be sited on a steep slope as this entails much excavation to provide storage capacity. In Unyamwezi, most of the valley bottoms are of clay soils or clay-sand mixtures which hold water satisfactorily, but, if there is any doubt of the water-holding capacity of the soil, holes should be dug in the proposed site, filled with water and their holding capacity tested. In the past two years, whenever possible, we have received approval from an officer of the Water Development Department before starting work on a dam.

The Size of the Dam.

The size of the dam depends on the topography of the dam site, the area of the catchment and the amount of probable run-off, and the area of rice-land to be irrigated. In the type of country where the majority of our dams have been built the average run-off during a normal wet season is approximately ten million gallons per square mile. Therefore if the catchment is estimated at two square miles, the dam should have a maximum storage capacity of twenty million gallons. We have built dams from half-a-million to fifty million gallons, but we consider that dams below one million gallons are hardly worth the work involved, and a dam of over ten million gallons begins to present mechanical difficulties best left to experts with a closely-supervised labour force. A million gallon dam, filling several times in the wet season, is sufficient for part-time irrigation of 10 acres of rice-land. As the primary purpose of the dam is to supply water during and just after the rainy season, the question of evaporation and the area of the dam in relation to its volume are not serious considerations.

Dam Wall.

The position and size of the dam wall are demarcated by two inner lines of poles and two outer lines of pegs. The lines of poles are six feet apart and mark the width of the top of the wall. The pegs mark the upstream and downstream limits of the slope of the wall. The level of the top of the wall is measured with a surveyor's level and is marked by nicks cut in the poles. A rope from the pegs to the nicks on the poles outlines the cross-section



of the wall, as shown in the diagram. In constructing small dams, we followed Longland in making the downstream slope of 1:1½ and the upstream slope of 1:2, but more recently we have followed the advice of the Water Development Department in making the downstream slope 1:2 and the upstream 1:2½, especially in the larger dams with 7-10 feet high walls or where the soil is not of the best consistency.

The site of the wall is dug six inches to one foot deep and all top-soil excavated from here or elsewhere is put aside for spreading on the surface of the finished wall and spillway. The surface of the site should be left rough to bind well with the soil tamped on to it. We have seldom found it necessary to make a puddle-trench and never a puddle-wall, and seepage under the wall has been negligible.

The earth from which the wall is made must not be clay which tends to slip when wet and crack when dry, nor powdery soil nor sand which lack cohesion, but a clay-loam which binds without cracking and does not settle unduly. This soil should be dug out of the basin of the dam, if possible, to increase its volume, and should be free from top-soil, stones, roots or any vegetable matter, and if any termite nests are present they should be dug out. The soil is dumped on the wall, spread, and vigorously tamped down so that it binds well. No more than six inches of fresh soil should be tipped on before each tamping. The wall should be built at full width, gradually narrowing with increasing height, not increasing in height and width at the same time. Earth should not be dug from within three yards of the base of the wall. If a dam has to be built when there is any danger of sudden floods, a gap should be left in the wall and then quickly filled in after the rest of the wall is finished and the spillways made.

The Pipe.

Water is drawn from the dam by one or more pipes which are laid either in the wall itself or preferably embedded in natural ground of the valley sides where inlet bays must be dug to take the water to them. Pipes should be laid level, higher than the bed of the dam to reduce the danger of silting, and should project at least a foot at either end. Good clay loam should be carefully tamped round the pipe to prevent seepage along it. The pipes should be laid high enough to command a big area of irrigable land, and yet be able to draw most of the water from the dam.

A suitable sized pipe is a three-inch diameter galvanized-iron pipe obtainable from Railway Stores in 18- or 21-foot lengths at Sh. 3/17 per foot. They are threaded at each end and are easily joined by threaded collars. One, one-and-a-half or two lengths are sufficient for these small dams. So far, the pipes have been stopped by softwood bungs at the outer or both ends, but these, though cheap and easily replaceable, have the disadvantage of sometimes becoming jammed, or of being too easily removed by children or malicious people. Screw-on caps are now obtainable and have proved satisfactory; stopcocks have not yet been tried.

The Spillways.

In earth dams it is essential that water should at no time be allowed to flow over the dam wall, and the spillway should be of sufficient size to take the excess water from the biggest floods. It is a mistake to skimp this part of the work as the safety of the dam depends very largely on it. The level of the spillway should be 2½-3 feet below the level of the top of the wall, and we have found that a width of 20 feet is sufficient for a dam up to two million gallons, but for the dam to

be safe in every possible flood, the Water Development Department recommends a width of 50 feet. In bigger dams it is preferable to have two spillways. The spillway should be level from top water level to the end of the dam wall and slope down gently (1:840 or 1:960) from there to the outlet so that no scouring occurs. The inlet and outlet should be at least 10 yards from the dam wall and precautions should be taken that spillway water cannot damage the wall. If the spillway is made wide and on a gentle slope as described above, it is rarely necessary to make any revetment or other protection against scouring.

Inlet Ditches.

If the natural catchment should prove insufficient to fill the dam, it can be increased by the construction of inlet ditches. These are about 1½-2 feet wide and 9 inches deep on a gentle slope (say 1:840) leading run-off water into the dam catchment. They should be cleaned regularly as they quickly silt up.

Similarly, if the catchment should prove dangerously large for the size of the dam, it can be reduced by ditches carrying run-off water away from the dam.

After-care of the Dam.

Provided that care is taken of the dam during its first wet season, it needs very little attention thereafter. The dam wall may sink a little, especially in the middle, even if tamping is well done, and more soil must be added. The layer of top-soil spread on the wall and spillway is full of seeds which soon produce a protective cover of grass and weeds. It is also advisable to heel in roots of suitable grasses at two feet intervals on the wall and spillway, stargrass (*Cynodon* spp.) being the best for this purpose. The most dangerous period is the first heavy rain on a newly made wall. On some dams we laid long grass (*Hyparrhenia*, etc.) as a thatch to shed the rain till the new grass came up, and this was found to be very effective. All erosion gullies and cracks in the wall must be filled up at once. If the basin or the wall should prove to be pervious, it can be improved by puddling in clay mud, but most dams which are at first slightly pervious will in time silt up and hold water naturally. In small dams such as these, no special protection is necessary to guard against wave action.

The Irrigated Area and Control of Cultivation.

Before the dam is begun, there must be an agreement with the local Native Authorities regarding the allocation of irrigable land, the compensation of people whose fields are destroyed in the work and the responsibility of drawing water from the dam. We found the best results were achieved when local custom was followed as closely as possible but when there was strict control by authority. The communal use of irrigation water is foreign to the Wanyamwezi, and without strict control there was constant bickering and no idea of co-operation. The water is led from the pipes through ditches running along either side of the rice valley. If the valley is flat and broad, ditches can also be made down the middle. The slope of these ditches must not be so great as to cause erosion, and it is advisable to put stones or a concrete block to prevent scouring at the outlets of the pipes. The walls of the ditch are narrow earth bunds similar to those of the rice-fields themselves.

The irrigable land is divided into rice-fields, the size depending on the slope of the land and on local preference. We found that 25 feet square was a popular and suitable size, but other tribes may prefer larger units. The surrounding bunds are built by the people to whom the fields are allocated.

The allocation of the fields must follow native custom, with priority given to those people who had already rice fields in the valley or who helped to make the dam. In Unyamwezi, the fields were allocated by the local chief or headman, each man getting a number of fields as agreed between himself and the chief.

Compensation for crops destroyed in the making of the dam should be generous.

The control of water must be closely supervised, and the pipes should be opened only by responsible persons when they are convinced that there is need for it. We have ruled that the pipes be opened and closed only by the local headman and agricultural instructor together, and that the people who want water on their fields should be present at the time to lead the water as it is required. Provided this method is used, water can be applied for the required time and can be led to any part of the valley desired by closing the ditches and making openings in the bunds of the rice-fields. Only thus can quarrelling and wastage of water be prevented.

As this communal use of irrigation water was new to the local people, we did all we could by talks and propaganda to accustom them to it. At first they were suspicious and there were rumours that Government was to charge rent for the use of the water or take a levy of part of the crop. Even after two years, though suspicion has been allayed, the people do not make full use of the dam water, even though its value must be obvious.

Other Uses of the Dams.

Although the dams have the primary purpose of irrigating rice-land, they have other valuable uses to the community. In the dry season any remaining water is used by people and domestic animals for drinking; in the drought of 1948-49 this must have saved many animals in Nzega and Tabora. The dams also provide washing water for the people and, incidentally, have provided good shooting. Several of the dams were sited to induce people to settle in areas cleared of tsetse bush so that their cultivation would prevent regeneration.

The Labour Force.

The Headman.—In such work, with European supervision so scanty, it is of the utmost importance to get as good a headman as possible and to spend much time in training him. We found that ex-army N.C.O.s were often suitable for this work as they were accustomed to the management of men. Written instructions in Swahili were given to each headman and this greatly reduced mistakes arising from misunderstanding or forgetting orders. Few African headman have the faculty, without training, of using their labour to the best advantage—for example arranging the numbers of men digging, carrying and tamping so that all are kept busy and the work is not hindered by the failure of any one section to keep up with the rest. Whenever possible, the headman should arrange for task-work to be done.

The Working Unit.—We have tried three types of working unit.

(*a*) Wholly hand labour.

(*b*) Hand labour plus dam-scoops and ploughs pulled by oxen.

(*c*) Hand labour with a mechanical unit, with or without oxen or dam scoops.

(*a*) Hand labour only was employed in tsetse country where oxen could not be used. The ground is dug with hoes, picks or mattocks, shovelled into wheelbarrows or earth-pans and dumped on to the dam wall where it is beaten down by tampers which are heavy blocks of wood about 10 in. by 8 in. by 4 in. fitted with a 4-foot handle. The carriers and wheelbarrows also help to consolidate the dam wall by passing over it. Apart from the headmen, all the labourers were local and many of them would benefit from the dam. They were the usual type of African labourers doing as little as they could get away with, but we had little trouble provided the headman was good. One headman could usually control up to 50 men satisfactorily, but above that a second headman was necessary. The distribution of labour must vary with every dam, but the following can be taken as a general guide, where 70 men are employed:—

- 1 headman.
- 1 underheadman.
- 35 men digging and filling barrows and basins.
- 25 men pushing wheelbarrows and carrying basins and tipping earth on to the wall.
- 7-8 men tamping.
- 2-3 men doing odd jobs such as removing roots and stones from the wall, replacing handles and carrying water.

One or two of the diggers may have a bonus as choir leaders.

(*b*) Oxen with dam-scoops and ploughs. In the heavy soil of the valley bottoms it is necessary to use four oxen for each dam-scoop or plough team. Two dam-scoop units are suitable for a small dam as more get in each other's way. Each unit requires a scoop-man, a guide and an ox-driver. A spare team is required to relieve the other teams as they tire quickly and should be changed over every two hours. A small boy is needed to herd the resting beasts. The dam-scoops used are of 5 or 7 cubic feet capacity. A reasonable working unit with two ox-teams for ploughing and pulling the scoops is as follows:—

- 1 headman.
- 1 headman in charge of ox-teams.
- 12 oxen.
- 7 men in charge of oxen.
- 20 men digging and filling barrows and basins.
- 10 men carrying and tipping soil.
- 10 men tamping.
- 2 men doing odd jobs,

(*c*) The mechanical unit, consisting of a Fordson Major tyred tractor, a Dragoon three-furrow disc-plough, and a 22-cubic-feet Killifer scraper, has only recently been completed and is working on its first dam so that I am not yet in a position to make any comments on its use.

Tools.

The tools and the numbers of each must depend on many factors including the preferences of the people themselves. For a labour force of 70 without dam-scoops we used the following tool supply, with a certain number spare to cover changes in the work being done.

- 35 digging-hoes.
- 10 picks or mattocks.
- 10 shovels.
- 10 wheelbarrows.
- 15 earth-pans or native baskets for soil-carrying.
- 10 tampers.
- 1 striding-level for levelling top of wall, spill-way and pipe.
- 2 crowbars for removing roots and stones.
- 2 axes and four machets for bush and tree cutting, and making handles.
- A few empty petrol-tins for water.
- Adjustable spanner, tin of grease and spare nuts and bolts for maintenance of barrows.
- Muster-rolls, labour-cards, pencils.
- Several boards are often useful to make a firm pathway for barrows over soft and broken land, or to the top of the wall.

If oxen are used, the following tools are required:—

- 1 plough with chains, yokes, etc.
- 2 dam-scoops with chains, yokes, etc.
- 20 digging-hoes.
- 5 mattocks or picks.
- 4 shovels.
- 4 wheelbarrows.
- 10 earth-pans or baskets.
- Other tools are as in the first list.

In dams of large area more scoops and ploughs can be used and the hand labour reduced.

Costings.

Dams vary so much that the costings of any one would give a wrong impression. The following figures are based on the study of several dams and give a fair idea of the total cost and proportion of various items. We have found that two months is a fairly usual time for making a dam with 70 labourers:—

	Sh.
(1) Headman—2 months at Sh. 60 ..	120
Under-headman—2 months at Sh. 30	60
(2) Labour 2,800 man-days at 60 cents	1,680
(3) Depreciation of tools (at 10 per cent of cost per dam)	100
(4) Transport of tools, equipment, headman, etc., to and from dam ..	100
(5) Assessment for European supervision	200
(6) Compensation for loss of crops ..	30
(7) Rent of house for headman and storage of tools at Sh. 10 per month ..	20
(8) Pipe 54 ft. at Sh. 3/17 per foot, 2 pipe caps at Sh. 8	187
	Sh. 2,497
	Say £125

By using dam-scoops the costs can be reduced. Assuming other items in the above list to be unchanged, item (2) for labour can be reduced to half, i.e. Sh. 840.

Cost of two dam-scoop units (2 dam-scoops and one plough).

	Sh.
Hire of oxen, 12 at Sh. 1 for 40 days ..	480
Two dam-scoop men at Sh. 1 for 40 days	80
Two leaders at 60 cents for 40 days ..	48
One herd-boy at 50 cents for 40 days ..	20
Housing of oxen	10
	Sh. 638
	Say Sh. 640

Thus Sh. 200 is saved by using two dam-scoop units.

Economics.

Cost of a 2-million gallon dam: £115-£125.

Irrigable area: 20 acres.

Estimated increase in yield of paddy = 200 kilo per acre × 20 = 4,000 kilo.

Tabora price of paddy 30 cents/kilo. Therefore annual value of increase of paddy yields due to the dam is £60.

Provided that full use is made of the irrigation water, it is theoretically possible for the cost of the dam to be paid off in two or three seasons.

Acknowledgments.

I wish to thank Mr. D. H. Edmunds of the Water Development Department and the Agricultural Assistants in the Western Province for their assistance in the preparation of this article.

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PEAR DRYING

By T. H. Jackson and Barbara E. Roger, Department of Agriculture, Kenya

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It is a characteristic of fruit-growing countries with only a small internal market that in years when crops are good there is generally a glut of certain kinds of fruit, with the result that as the season advances, prices fall below the cost of production. Most growers realize that the situation can be alleviated by better distribution and marketing, but few are aware that some kinds of fruit can be processed on the farm with inexpensive equipment, which changes an extremely perishable commodity into one which will keep indefinitely.

The process of fruit drying is a simple one, and is carried out in many fruit-growing countries; in California 14.5 per cent of the annual pear crop is utilized for drying. Pear drying can be done by the heat of the sun or by means of artificially heated driers or kilns.

In Kenya very nearly all the dried fruit consumed is imported; this in a country which could probably grow and produce its total requirements, and even develop an export trade.

One of the most widely planted deciduous fruits in Kenya is the Keiffer pear, of which there is quite often a glut on the market. Gluts are likely to become more frequent as new plantings come into bearing, unless some form of processing the fresh fruit is adopted.

With this situation in mind trials on drying Keiffer pears were carried out at the Department of Agriculture, Horticultural Station, Molo, in 1949. Two trials were made, the first with fruit selected from the trees for the purpose, and the second with fruit either damaged, or too ripe for marketing fresh.

For the first trial, sound, mature fruit was picked from the trees, and ripened in store for several days.

It is important that pears for drying should be at the eating-ripe stage, but over maturity will result in excessive bleeding during the sulphuring process.

After ripening, the fruit was graded for size, the stalks pulled out, and the fruit cut in halves longitudinally, the calyx at the opposite end of the fruit to the stalk, was also cut out.

The cut halves were placed in trays, cut side uppermost, and in single layers.

The next process, that of sulphuring, is necessary in the preparation of most kinds of dried fruit. Sulphuring consists in burning a pure grade of sulphur, specially manufactured for fruit drying, in a closed compartment. The trays of fruit are stacked over the burning sulphur so that the sulphur dioxide gas given off passes up through the trays and is absorbed by the fruit. It is important that the sulphuring chamber should be airtight except for two small ventilation holes. In the trials, sulphuring was carried out by stacking the trays of cut fruit in a large wooden box; a space about 12 inches deep was left under the trays. Sulphur was burnt in a small iron basin standing on the floor of the box. No fruit-drying sulphur was available at this time and ground sulphur had to be used. This grade is not sufficiently pure for fruit drying, in burning it produces a black slag which forms a crust over the burning sulphur with the result that combustion is stopped before all the sulphur is consumed. The use of impure sulphur in connexion with fruit drying is wasteful. The sulphuring chamber has to be opened frequently in order to see that combustion is still going on, with consequent loss of gas. The time required for sulphuring pears for drying is generally given as from 24 to 48 hours; in these trials the fruit was sulphured for 8 to 12 hours only; this period has given satisfactory results.

On removal from the sulphuring chamber the pears appeared as freshly cut, the cut surfaces were moist and there was no browning. The skin of the fruit had a translucent appearance. Some pears cut at the same time, which were not sulphured, as an experiment, had turned brown and dried on the cut surface.

The fruit was put into the drier on the same trays on which it was sulphured. The drier used in the trials was a small forced-draught pyrethrum drier. Any type of drier which is successful for pyrethrum should also be suitable for fruit drying. Medium-sized fruit dried in about 20 hours, small fruit in about 18 hours, whilst very large pears took as long as 40 hours. Thus the necessity for grading the fruit for size and traying the different sizes separately is evident. A mixture of sizes on the trays results in the small fruit being overdried before the large ones are ready. The

correct time at which to remove the fruit from the drier is learnt by experience. Properly dried fruit is firm without being hard, and the cut surface should be fairly flat with a creamy colour, and the skin a clear yellow. Over-dried fruit is brittle especially round the edges, which curl inwards over the cut surface. After removal from the drier the pears were stored in boxes for a few days; this has the effect of evening up the moisture content of the individual fruit; slightly over-dried fruits taking up moisture from those surrounding them. Cooking trials were carried out with samples of the dried fruit, which was first soaked in water for 24 hours. The cooked pears had an attractive appearance and an appetizing flavour; the samples compared favourably with imported dried pears.

Unsulphured pears after drying had a very unattractive appearance, the skin and cut surface were a very dark brown, and the shape of the fruit was very much distorted. They had an unpleasant flavour when cooked.

In the second trial carried out, 351 lb. of Keiffer pears, all of which were unsuitable for marketing as fresh fruit owing to damage by Fruit Sucking Moth and over-ripeness, were used. The loss in cutting and grading this fruit was 123 lb., leaving 228 lb. suitable for drying.

Sulphuring and drying was carried out as in the first trial. After drying the total weight of dried pears was 57 lb., a ratio of 4 lb. of fresh fruit to 1 lb. dry. The dried pears in this trial were classified into three grades, but there was a high proportion of second and third grade owing to the poor quality of the fresh fruit. It must be emphasized however that all these pears would have been a total loss to the grower if they had not been dried.

Dried pears pressed in blocks, approximately four by six by two inches, and wrapped in cellophane, formed an attractive pack which would be suitable for marketing.

This pack is easily carried out by lining a loose-bottomed wooden box with cellophane; the pears are laid into the box in about four layers. A wooden block, which fits the box, is put in on top of the pears, and the whole pressed in a vice.

Samples of dried pears produced in these trials, submitted to a number of firms and individuals were favourably commented on by all. After being stored at Molo for seven months the pears show no sign of deterioration. There is little doubt that pears produced in this way would find a favourable local market, and might also be suitable for export.

Our thanks are due to J. P. Ryan, Esq., and Messrs. Simpson and Benson, of Molo, for donating the fruit without which these trials could not have been carried out.

NOTES ON SHEDS AND EQUIPMENT FOR DRYING HIDES AND SKINS

Compiled by the Department of Veterinary Services, Kenya

(*Received for publication on 17th July, 1950*)

Defects Commonly Found in Existing Sheds

The majority of existing hides and skins drying sheds have the following defects:—

The drying sheds are too small in proportion to the number of hides and skins to be dried, so that half-dried hides and skins are often removed from the frames to make place for fresh ones. This removal results in putrefaction affecting the prematurely dried hides and skins.

The frames in the drying sheds are also too small, because they do not allow the hide or skin to be laced suspended free of the poles in the frame, and it is a common practice to fold the ends and edges of the hide or skin around the poles. Such procedure causes obstruction to the free circulation of air and any portions folded around the structure of the frame become putrid and partly taint the hide or skin. These putrid parts must be trimmed off with consequent loss in weight of the hide or skin.

The frames may touch or be too close to the outer walls of the shed and so encourage access of birds, dogs, hyenas and other vermin.

The frames may be placed too close together and prevent the freest circulation of air, or the frames may be separated too far apart and cause a waste of valuable space.

Drying sheds are often built so far distant from slaughterhouses and butcheries, etc., that hides and skins require to be transported to them. This often leads to delay before curing takes place which may result especially during the heat of the day, in hair-slip and putrefaction.

Water supplies are often so inadequate that fresh hides and skins cannot be washed immediately after flaying. This is important since unless this is done blood and manure will cause coloration of the hide tissues.

In the absence of storage facilities dry hides and skins are often stacked on the top of frames causing them to break or bend and thus preventing air circulation. In this position drying hides are extremely susceptible to insect and bacterial contamination.

Thatching for roofs when used usually provides insufficient slope and also insufficient overhang to protect against rain. Corrugated iron roofs may also suffer from the latter defect.

Drying sheds are often built on low ground and are not provided with drainage for rainwater so that floors may become saturated during rainy seasons.

In the absence of frames sheep and goat skins are often tied to walls and to roof trusses thus interfering with ventilation and providing dogs and hyenas, etc., with an easily accessible meal.

Fleshing tables are often too small and when placed outside the drying shed become warped and cracked which makes fleshing difficult on an irregular surface and may cause injuries.

Sharp-pointed knives are generally used for flaying and fleshing of hides and skins which in careless hands often cause injuries. A proper knife should be at least six inches long with a convex blade, having a blunted or rounded end.

*Points to be Noted in Erecting Shed from Approved Design**

It is not difficult to build a suitable and serviceable drying shed even when means available are limited and materials somewhat primitive, provided a good plan is followed and care is taken to avoid the defects already described.

Even the smallest shed should consist of three distinct parts:—(i) working space; (ii) drying space; (iii) store.

Working Space.—The floor should be of cement or some impervious material sloping rapidly (½ inch to 1 foot) towards the external wall against which the fleshing table is placed. A draining rack is used for spreading out the hides and skins on their arrival at the shed when they are brought in while the attendant is absent or occupied with other hides and they have been washed or arsenicated and it is required to allow the liquid to drain off them. It is important that fresh hides and skins should not be left in a heap on the floor.

* A plan of suitable sheds and drying equipment may be obtained from the Director of Veterinary Services, P.O. Kabete, Kenya. This plan is included in "A Handbook for the Hides and Skins Industry", by Dr. I. Mann, which is also obtainable from the Director of Veterinary Services.

The top of the fleshing table should be smooth and its edges rounded. It should be made of seasoned wood to avoid warping and separating between the planks. A sheet of aluminium or similar material fixed to the top of the table can be used to great advantage.

An arsenication tank may be included, but would actually be omitted in most rural sheds, where hides are sold as they are dry. Where the distance to the exporter's store is great, or where the shed is built by an exporter, a municipality or an abattoir, such tank will prove essential in reducing the damage done by insects.

Drying Space.—Anticipating that an average of seven days is required to dry a hide or skin, the calculation of the number of frames needed is as follows:—

For a supposed daily kill of three cattle and eight sheep or goats—

Three cattle hides require ..	3 frames
Eight sheep/goats skins require	2 frames
	5 frames
Drying period .. 7 days	
	7 × 5 = 35 frames

Therefore, a shed holding 35 frames would be sufficient for a daily kill of three cattle and eight sheep or goats.

Seven days drying is rather a long time for sheep and goat skins—but is on the safe side—and, as a cattle hide may, during wet weather, take up to ten days to dry, it is considered that seven days can be reckoned as an average period.

If the kill includes European cattle, the size of the drying frames should be 10 ft. × 9 ft., when only native cattle hides are to be dried, 10 ft. × 8 ft. dimensions will be found sufficient.

Store.—The size of the store depends on the number of frames required for the weekly kill, for the handling of green hides from the local market and/or the immediate vicinity. The shed should not be used as a trader's store for the reception of dried hides and skins from other sources, for which it is not registered.

Hides and skins, in accordance with law, must be stored on a raised slatted platform, not less than six inches from the floor. These platforms should be arranged so as to allow a three-foot passage between them and the doors opening out of the drying space and/or out of the store. When possible the boundary or outer walls of the store should be built of stone or reinforced cement, brick or daub/wattle, up to a height of six feet, and the remainder of the wall up to the eaves of the root, of expanded metal or close wire-netting. Such form of construction will allow plenty of light and air to enter the store, render it vermin proof and enable the whole of the floor space (except passage for doors) to be used for storage. Should the outer walls consist only of open sides made of expanded metal or close wire-netting, etc., a two-foot passage will be necessary between the boundary wall and the raised slatted platform to prevent damage by rain and vermin.

Siting of Sheds

The following points should be noted in the siting of sheds:—

The hides and skins drying shed should be sited as near as possible to the permanent source of supply of raw hides and skins, such as abattoirs, markets, larger villages, etc., so that the fresh hides or skins can be cleaned and suspended with little delay and thus prevent the common defects of hair-slip and putrefaction.

The medical authorities should be consulted in the selection of a site.

The site should preferably have a slight slope so as to help in the disposal of effluents by gravity, into a drainage pit.

In accordance with law, the floor must be made of an impervious material which can be cleaned to the satisfaction of an inspector.

An ample water supply is a considered necessity for the prompt cleaning of the hides and skins of any blood and manure taints and the cleaning of the floor. If the drying sheds cannot be connected with any general water supply, a water tank or tanks of sufficient size should be erected on trestles to catch the rain supply from the roof. The ideal way of washing a hide or skin on both sides is under running water, with the aid of a good hard broom or brush, and not by immersion, therefore, a length of hose pipe should lead water from the tank to a point about one foot above the middle of the fleshing table.

Drying Equipment

Suspension drying equipment is used by those producers who prepare the odd hide or skin and are not able to take the hide or skin to a drying shed without delay. The erection of a frame or rack in their own *bomas* will permit the hides and skins to be suspended quickly, after preparing, and so prevent such defects as hair-slip and putrefaction, with subsequent devaluation.

MOUND CULTIVATION IN UFIPA, TANGANYIKA

By Murray Lunan, Department of Agriculture, Tanganyika

(*Received for publication on 22nd June, 1950*)

Ufipa District in south-west Tanganyika consists, for the most part, of a plateau (altitude 5,000-7,000 feet), covered with tall grass and with only scattered trees, apart from a few patches of hill forest. Each dry season, the pastoralists burn off this tall grass over nearly all the district, presumably to provide fresh grass for their cattle and to reduce ticks. Agriculturally, the Wafipa are very primitive. They do not put manure on their fields, unless ordered to do so, on the grounds that they have always in the past managed to grow enough food to survive without using manure. The land would become very deficient in humus were it not for the system of mound cultivation practised by the Wafipa. The method of cultivation in the plateau generally follows a rotation starting with mounds, followed by flat cultivation, followed by rough mounds, followed again by flat cultivation and then by ridge cultivation.

The rotation begins during February to April when the grass is cut and put in small heaps. The sod is then cut by hoe and piled in neat circular mounds of upturned divots over the heaps of grass, each mound being about 3 feet in diameter and 2-2½ feet high as shown in the photographs. The distance between one mound and the next is 1-2 feet. It is estimated that one man can make 100 mounds in a day. The customary crop on the mounds is beans, though sometimes cassava and sweet potatoes and rarely chick-pea and wheat are planted. The women plant 10-15 beans on the top of the mound (*see* Fig. 11), and the crop is harvested in June and July.

Weeding begins in October and the weeds are thrown on the mounds. In late November or in December, when the rains have begun, the mounds are broken down and spread over the field. By this time the grass and turf are rotted down. When the soil is damp enough, the field is planted on the flat with finger millet and sometimes maize. Alternatively, seed may be broadcast and the mounds spread over them. If cassava is planted, it is always put at the base of the mound and left in the field when the mound is broken down, so that it continues to grow among the finger millet and maize.

By June or July, all the millet and maize has been harvested and the fields are left till November when the people make small rough mounds covering heaps of weeds and crop residues. These mounds are left till the following January when they are broken down and spread, and the fields again planted with finger millet (rarely maize) which is harvested about the following June, and the field left in its flat condition.

Fig. 1

Fig. 2

In the following December the field is ridged and planted with maize interplanted with groundnuts, beans or Bambarra nuts, or occasionally left flat and planted with groundnuts alone. This may be repeated for several years until the soil is exhausted and then it reverts to grass and weed fallow.

If bushes or small trees are encountered in the field during the first mound cultivation they are cut down, put in a heap, and surrounded by a ring mound. If there are large trees, the branches are cut, heaped round the trunks and surrounded by a ring mound. The branches in the heap are burned at the end of the dry season and pumpkins customarily planted in the rings. The cultivation rotation then goes on as described above, but there is no methodical spreading of the ashes over the field, and there is no burning of trees outside the cultivated area to collect the ashes.

Mound cultivation has been condemned as being wasteful of trees, but in Ufipa this is rarely so. It may be conducive to erosion but the main mounds are made in March and April when most of the season's rains are over. Effective erosion control could be achieved by joining the mounds by small ridges or a few divots. Its merit appears to be that it incorporates the grass in the soil to rot down to humus instead of being burned in the annual grass fires.

I am indebted to Mr. W. E. Yeo, Agricultural Assistant, and Mr. Adolph Milunga, Grade III Instructor, for assistance in collecting material for this article.

BOOK REVIEW

East African Agriculture.—Edited by J. K. Matheson and E. W. Bovill, published by Geoffrey Cumberlege at the Oxford University Press (1950), pp. 332 with 32 plates. Price 25/-

In the preface the editors state "Our object has been limited and unambitious. We have not aimed at producing either an authoritative text-book or a manual of instruction. This volume is descriptive rather than instructive. It does not pretend to tell the reader how to grow anything, only how it is grown, which is a different and much simpler matter". This objective has been achieved with great success, and the book is one which should have a wide appeal. Verbosity and unnecessary detail have been avoided, and the photographs are well chosen and clearly reproduced.

While the editors have written many of the chapters, and have obviously edited with care those written by others, the book is a collection of descriptions and opinions by men who have specialized in one or more of the numerous branches of agriculture in East Africa. The chapter headings show the wide range of subjects, which include soil conservation, research, cereals, cinchona, coffee, essential oils, fruit, groundnuts, livestock, papain, passion fruit, pyrethrum, rubber, sisal, sugar, tea and wattle. The section on estate accounts will be of practical value to many farmers, since it is only by simple but effective costing that the best financial returns can be obtained from farming.

While there is a bias towards European farming, native agriculture has a fair share of the text, and agricultural officers of long experience have contributed summaries of the methods used by native cultivators in Kenya, Tanganyika, Uganda and Zanzibar, while native labour and native welfare are described by the editors.

A number of appendices give data on rainfall, temperature, population, exports and labourers' rations, and every effort has been made to make the book worthy of a prominent place on the farmer's bookshelves.

A point worthy of mention is that "Practically the whole of the literary matter has been contributed without remuneration, and in the same spirit the sums received by the editors by way of royalty on the sales of the book will, after deducting expenses, be presented to the East African branches of the British Legion".

D.W.D.

THE BIOLOGY AND CONTROL OF THE CASSAVA SCALE

By G. Swaine, Entomologist, Department of Agriculture, Tanganyika

(*Received for publication on 5th September, 1950*)

According to the Department records, first observations in Tanganyika of the Cassava scale, *Aonidimytilus albus, Ckll.* were made in the Rufiji District in January, 1947. Two and a half years later, in July, 1949, reports were received that this insect was heavily attacking cassava on Ukerewe Island. By November of that year the infestation had become widespread on the mainland around Mwanza and in May, 1950, the insect was reported from Ukara Island, north of Ukerewe. Cassava scale has therefore only recently established itself as a pest of importance here.

Nature of Damage

The insects are generally to be found on the stem of a cassava plant (Fig. 1) and occasionally on the petioles. The damage, which results from the sucking habit of the insect depends largely on whether heavy encrusting populations of the scale build up during the early stages of growth of the plant or later on when the plant has become well established. In the former case the leaves lose their chlorophyll and gradually dry up; this is followed in a heavy infestation by a complete desiccation of the stem and ultimate death of the plant. Those plants which manage to survive an early infestation of this type are generally found to have poorly developed roots which are stated by the African to be unpalatable. When heavy infestation occurs later in the development of the plant the symptoms of attack noted above are only shown to a slight degree, but the roots must be dug out within a few months or they too become inedible.

Description

The adult female is bag-shaped, possesses neither wings nor legs, and is reddish-purple in colour. It is completely covered dorsally with a silvery-white scale of a waxy nature, approximately 2-3 mm. in length and shaped like a mussel shell. (Fig. 2.) Anteriorly and dorsally can be recognized two golden-brown, oval-shaped patches; these are the remains of the first and second nymphal skins which have become incorporated into the adult scale. On the ventral surface the insect is bounded by a soft, cottony secretion which is closely adherent to the stem of the plant. The male scale is of the same colour as the female but shorter in length (approximately 1.1 mm.) and with the edges of the scale covering more nearly parallel. Only one nymphal skin, the first, can be recognized on the anterior dorsal surface. Unlike the female, the male in the adult stage is of typical insect form possessing means of locomotion in its three pairs of legs, and fragile but well-developed anterior wings.

Sex Ratio

Counts made on 675 individuals showed 306 to be males and 369 to be females, i.e. males and females are produced in approximately equal numbers.

Life-history

The eggs are laid by the adult female at the posterior end of the body and deposited between the upper scale covering and the lower cottony secretion. The number of eggs produced has been found to vary between 27 and 76, with an average for 25 females of approximately 47. As the eggs are laid the female gradually shrinks in length and finally shrivels up.

In the laboratory hatching has been observed to occur in about four days' time. The nymphs (Fig. 3) which develop from the eggs are oval in shape, 0.2 mm. long by 0.15 mm. wide, and have a depressed, pale-pink body with two conspicuous black eye spots anteriorly. They are capable of active movement, a rate of progress of approximately 18 inches per hour having been measured in the field, and are the means by which dispersal is effected. On account of their appearance when moving these first nymphs are generally known as crawlers.

The subsequent life-history has only been followed in detail in the case of the female. After a period of from one to four days the crawler settles down, usually in the angle of a node of the stem, and proceeds to throw out two or three conspicuous white threads. These are shortly followed by numerous fine threads which, starting at the posterior end, slowly extend over the whole body covering it in about two days. The first moult then occurs approximately 11 days after the crawler settles, i.e. 12 to 15 days after the egg hatches. The cast crawler skin becomes incorporated into

the anterior end of the dorsal scale which is now produced by this second nymphal stage. Unlike the crawler this second nymphal stage is immobile, being devoid of legs. It now produces posteriorly a crescent of fine white threads which spread forwards in two to three days to cover the upper surface of the scale. On the fourth day the second moult occurs resulting in the production of the adult female. As before the exuvia become incorporated in the dorsal scale covering.

The adult female begins to lay eggs after about two days which therefore gives a total life-cycle of 22 to 25 days.

Both in the field and in the laboratory breeding has been found to occur regularly throughout the year. Owing to this, and the fact that the egg-laying period is somewhat extended, overlapping generations are rapidly produced. This means in effect that the mobile, infective crawler stage is present at all times of the year.

Dispersal in the Field

The possible means by which infestation could spread from plant to plant and field to field are:—

(*a*) By winds dispersing the crawlers.

(*b*) By active migration of the crawlers over the ground.

(*c*) By the passage of crawlers from infested to clean material when the cuttings are bundled prior to planting.

No evidence has been found in the field that either of the first two possible methods are of great importance. In heavily infested fields it has been frequently observed that uninfested plants are adjacent to infested ones. An experiment was laid down in March, 1950, at the Ukiriguru Experimental Station designed to assess the importance of spread of infestation from infested to clear plants by active migration of the crawlers along and between the ridges of the field. Results have shown that spread of infestation by this means is only of secondary importance. The percentage of clean plants newly infested was 37.2, the infestation averaging slightly less than one scale per plant. No difference was found between the cross-infestation obtained along the ridges in the field and that between the ridges. On the other hand planting of clean and infested cuttings in the same hole resulted in an average infestation of 9.3 female scales per original clean cutting with a percentage of 86.0 newly infested plants. Bundling of clean and infested material would thus appear to be the main way by which dispersal is effected. Spread over a wide area, e.g. from Ukerewe Island to Ukara Island during May, 1950, is undoubtedly due to this factor.

Control

Control of the standing infestation in the field is ultimately achieved by the predaceous ladybird beetle, *Chilocorus distigma, L.* Observations both at Ukiriguru and in the north Mwanza area indicate however that this predator only becomes of real value when heavy populations of scale insect have developed. In order to prevent the build-up of damaging populations of the scale on the more susceptible newly planted material it has therefore been necessary to investigate other methods of control designed to prevent spread of the crawlers at the critical time of planting.

The most obvious method is that of selecting clean planting material to begin with. A survey made in the Mwanza area, three months after this recommendation was made, showed that the general level of infestation had decreased considerably.

Recognizing the possibility of a shortage of clean planting material an experiment was carried out at Ukiriguru in March, 1950, to test the efficacy of varying concentrations of a D.D.T./oil emulsion in controlling the infestation on heavily attacked cuttings. The details of the experiment are given below:—

Treatments

(1) Control
(2) 2 per cent D.D.T.
(3) 1 per cent D.D.T.
(4) 0.5 per cent D.D.T.
(5) 0.25 per cent D.D.T.
(6) 0.1 per cent D.D.T.

Cuttings dipped for 5 minutes and allowed to dry completely before planting.

Forty-eight cuttings per ridge, 13 ridges per block, alternating empty and treated ridges. Each treatment cutting planted with a clean cutting in contact with it.

Randomization of Treatments

Block 1	·5	·6	·4	·2	·3	·1
" 2	·6	·2	·3	·4	·1	·5
" 3	·4	·5	·6	·3	·2	·1
" 4	·1	·2	·6	·5	·4	·3
" 5	·3	·2	·1	·4	·6	·5

Assessment

Counts of live adult female scales were made on ten "clean" cuttings selected at random in each row. These scales derived from crawlers which had passed across from the treated cuttings in contact with the clean cuttings and the numbers recorded therefore give a measure

of the killing and residual properties of the treatment. The figures are tabulated below:—

Treatment Totals

Block	% D.D.T. Concentration					Control
	0·1	0·25	0·5	1·0	2·0	
1	38	9	8	14	24	162
2	7	8	8	5	11	59
3	12	17	15	17	88	68
4	11	47	44	24	3	153
5	15	11	16	20	5	23
Combined Block Totals	83	92	91	70	131	465

Statistical treatment of these results, kindly carried out by Mr. H. Doggett, shows that all the D.D.T. treatments were significantly better than the control, $P = 0.05$, but that there were no differences between the D.D.T. treatments themselves. Whilst D.D.T. emulsion will effect good control it was observed that the germination of both treated and untreated cuttings, all originally heavily infested, was extremely poor.

Counts over all the five blocks showed that the percentage germination of these cuttings was only 1.2.

The use of D.D.T. is to some extent therefore invalidated. In view of the difficulty of deciding whether or not it would be worth while to disinfest cuttings bearing different populations of scale, which would have to be assessed by eye, it is recommended that the most readily workable control is to select clean planting material only. As some minor cross-infestation does occur between the growing plants a further recommendation is that any infested cassava remaining in the field when the clean new cuttings are being planted should be pulled up and burned. It is not enough merely to pull up such plants and leave them on the ground as they remain infective for a period of up to ten days.

Summary

(1) Descriptions are given of the damage caused by the Cassava scale insect to the plants. Young plants are more adversely affected than old ones.

(2) The life-history and brief descriptions of the different stages are given and the means by which dispersal is effected in the field by the infective crawler stage are indicated. Bundling of clean with infested planting material is considered to be the most important factor in this dispersal.

(3) Control methods are discussed in detail. The beneficial effect of a D.D.T./oil emulsion is largely vitiated by the very poor germination of the infested cuttings. The main line of control is by the selection of clean planting material and the uprooting and prompt burning of any infested cassava remaining in the field at the time of planting.

ACKNOWLEDGMENTS

I wish to acknowledge the great assistance given me by the Botanist, Mr. H. Doggett, both in supervising the planting out of experiments and interpretation of results. My thanks are also due to Mr. J. Peat, Chief Scientific Officer at the Empire Cotton Growing Corporation, Ukiriguru Experiment Station, for his permission to use land and for his provision of labour for the experiments. I am also indebted to the Director, Commonwealth Bureau of Entomology for identification of the scale insect.

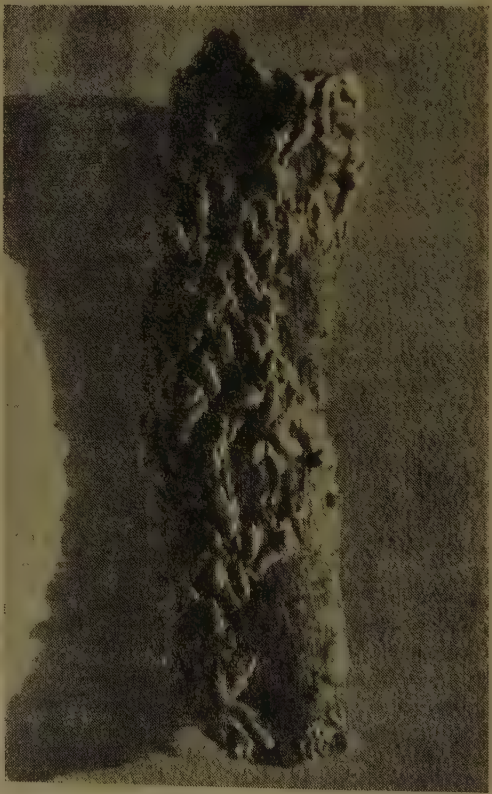


FIG. 1—Stem of cassava plant heavily infested with scale.

FIG. 2—Female scale insect, dorsal view.

FIG. 3—Cassava scale crawler, ventral view.

A NOTE ON THE ESTIMATION OF LIVEWEIGHT OF CATTLE IN UGANDA

By H. L. Manning and E. Williams (Empire Cotton Growing Corporation and Department of Agriculture, Uganda)

(*Received for publication on 14th June, 1950*)

Experience has shown that certain preventative inoculations given to cattle must be closely related to liveweight if they are to be both effective and safe. Except on experiment stations facilities for weighing are limited, so that estimates must be made either by eye judgment, or on some index based on simple measurements. So few people can estimate weight, within defined limits, that it was considered worth while to determine the relationship between some simple measurements and liveweight in an experiment station herd, and to derive therefrom a simple formula for estimating the latter. Bullocks chosen for this study were raised at the Serere Experiment Station in the Teso district of Uganda and were of a uniform zebu type.

Various formulæ have been derived for studies of this nature and are available in many text books. In general they are based on some simple function of girth and length and lead to a figure which is proportional to cubic capacity. In this study the writers have assumed that the major contributions to variation in weight are those due to, or correlated with, differences in the cylindrical volume of the torso from the hump to the pin bone. This volume may be represented by $3.14 \times r^2l$ where length is defined as the distance from the base of the hump to the pin bone, and the radius squared is derived from the maximum girth using the constant 7/44 squared (0.0253). Since the two constants 3.14 and 0.0253 appear in all cubic capacity estimates they may be ignored. The arbitrary estimate of capacity reduces simply to $(\text{girth})^2$ multiplied by length and this estimate, which is given in column 4 of Table 1, can be converted to cubic inches by multiplying by 0.0253×3.14 and one hundred thousand.

Data for girth, length, index of capacity, liveweight and expected weight are given for 82 beasts in Table 1. By use of the usual regression formulæ, the expected value of weight for any beast is given by the identity—

$$Y_E = 89{\cdot}47 + 358{\cdot}62\, X_i$$

For example a beast with a girth of 70 in. and length 40 in. would have an index of capacity of 196,000 ($70^2 \times 40$) which is coded to 1.96 and the expected weight is therefore 792.4 lb.

The regression of actual liveweight on the index of capacity is given by the regression coefficient b = 358.62 from which it may be inferred that an increase of one coded unit of capacity results in an average weight increase of about 359 lb.

It has long been known that liveweight estimates may be derived from simple formulæ which for the most part have been based on experiments in temperate countries. At the same time it is reasonable to expect that such a general relationship would not be very precise when applied to particular beasts. In this case the linear regression estimate for a specific herd has in fact led to reasonably high precision which is demonstrated in the analysis of variance below.

Analysis of Variance

Variation Due to	d.f.	Sums of Squares	Mean Sq.	Variance Ratio
Regression of weight on capacity ..	1	2310239·7	2310239·7	1026·82
Deviation from regression	80	179993·3	2249·92	
Total variation ..	81	2490233·0		

The above analysis shows that the linear regression of liveweight on capacity—arbitrary though it is—has accounted for a very large proportion of the variation in weight. The value of R^2 is 0.928; that is, some 93 per cent of the total variation in liveweight may be accounted for by variation in capacity.

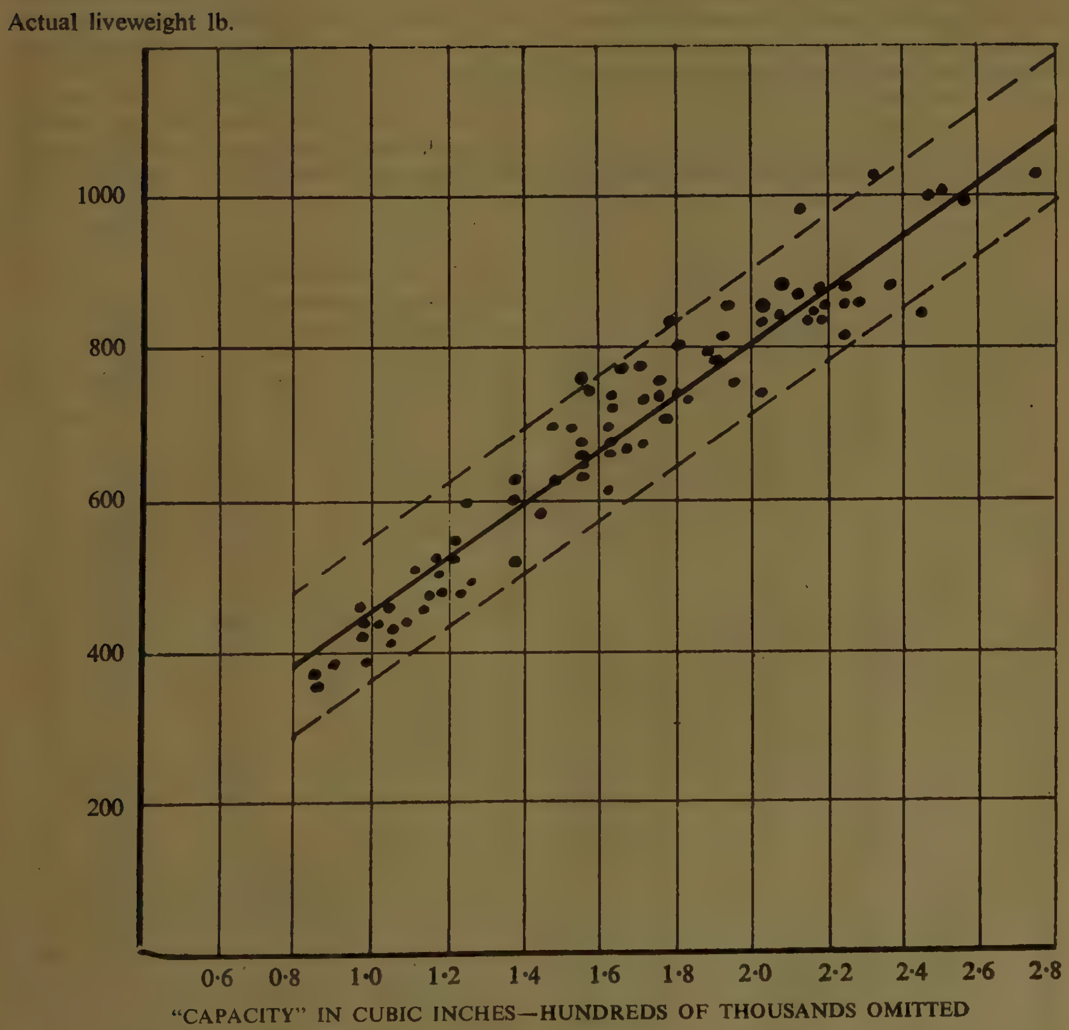
In Figure 1 is given a correlation diagram on which actual liveweight is plotted against estimated cubic capacity. The cubic capacity estimates and actual weights of the 82 beasts are given, and also the regression (solid line) for weight on capacity calculated from the identity 89.47 + 358.62 X.

The veterinary officer concerned with the calculation of dosages wishes to know not only what is the best estimate of weight but also what are the limits of error to which that estimate is subject. Statistical estimates of these limits are known as *fiducial limits* and a standard of accuracy commonly adopted is that set by the 1 in 20 chance. That is to say, the 1 in 20 fiducial limits are those within which

FIG. 1

RELATIONSHIP BETWEEN LIVEWEIGHT OF CATTLE AND CUBIC CAPACITY
EXPECTED VALUES FROM REGRESSION EQUATION

Confidence limits thus — — — —



the true weight would lie 19 times in every 20 trials. The fiducial limits are calculated from the deviations from the regression line. The mean square due to these deviations is given in the second line of the analysis of variance above. The square root of this gives the standard error of the regression coefficient and is

$$Sy{\cdot}x = \sqrt{2249{\cdot}92} = \pm 47{\cdot}43$$

Sy.x multiplied by the value of t appropriate to the number of degrees of freedom available (*see* any standard book of statistical tables) gives the fiducial limits. In this case t for $p = 0.05$ with 80 d.f. is 2.0 and the fiducial limits are therefore

$$\pm 2{\cdot}0 \times 47{\cdot}43 = \pm 94{\cdot}86$$

These limits are plotted as dotted lines in Figure 1. Thus only once in 20 trials will the true weight deviate from the estimate by more than 95 lb. Though this appears a large degree of uncertainty, it should be remembered that a fairly high standard of precision is set. For veterinary purposes it is probable that a standard of precision that will only be transgressed once in five trials would be adequate, and for such limits the appropriate value of it is 1.28 and the fiducial limits are ± 61 lb.*

Summary

Preventative inoculations in cattle must be closely related to liveweight. Since scales for weighing are only available on large experiment stations a rapid field estimate is likely to be useful provided the confidence limits are not too wide. Such an estimate with appropriate confidence limits has been derived from a linear regression formula for a herd of Teso cattle.

TABLE 1

GIRTH, LENGTH AND LIVEWEIGHT OF BULLOCKS

EXPECTED VALUES YE FROM 89·47 + 358·62 × (*See* TEXT). "CAPACITY" HUNDREDS OF THOUSANDS OMITTED

Beast	Girth	Length	"Capacity"	Weight	YE	Beast	Girth	Length	"Capacity"	Weight	YE
1	72	41	2·13	888	853	43	75	39	2·19	836	875
2	68	39	1·80	749	735	44	66	37	1·61	662	667
3	73	42	2·24	810	893	45	62	36	1·38	605	584
4	55	34	1·03	453	459	46	70	39	1·91	808	774
5	67	35	1·57	743	653	47	76	43	2·48	997	979
6	71	42	2·12	863	850	48	58	36	1·21	470	523
7	66	37	1·61	673	667	49	64	36	1·47	622	617
8	68	39	1·78	831	728	50	75	40	2·25	852	896
9	71	41	2·07	839	832	51	68	38	1·76	741	721
10	72	39	2·02	734	814	52	67	37	1·66	662	685
11	65	37	1·56	672	649	53	65	38	1·61	686	667
12	64	38	1·56	664	649	54	58	35	1·18	505	513
13	64	38	1·56	627	649	55	72	42	2·18	870	871
14	66	40	1·74	754	714	56	74	40	2·19	846	875
15	68	38	1·76	696	721	57	74	41	2·25	850	896
16	72	41	2·13	836	853	58	66	43	1·87	793	760
17	71	40	2·02	850	814	59	74	43	2·35	870	932
18	67	40	1·80	798	735	60	65	38	1·61	731	667
19	80	38	2·43	835	961	61	74	40	2·19	813	875
20	60	38	1·37	622	581	62	57	38	1·23	481	531
21	76	40	2·31	1,023	918	63	66	38	1·66	772	685
22	62	37	1·42	578	599	64	51	33	0·86	366	398
23	79	40	2·50	1,000	986	65	55	32	0·97	420	437
24	75	40	2·25	876	896	66	53	32	0·90	381	412
25	71	38	1·92	846	778	67	55	33	1·00	431	448
26	82	41	2·76	1,026	1,079	68	50	33	0·83	365	387
27	74	38	2·08	880	835	69	55	32	0·97	393	437
28	80	40	2·56	994	1,008	70	56	33	1·03	418	459
29	66	35	1·52	754	635	71	54	34	0·99	436	445
30	65	37	1·56	642	649	72	57	35	1·14	468	498
31	71	40	2·02	831	814	73	56	34	1·07	430	473
32	69	38	1·81	727	739	74	56	35	1·10	503	484
33	67	38	1·71	663	703	75	58	34	1·14	451	498
34	63	37	1·47	693	617	76	57	37	1·20	518	520
35	69	40	1·90	784	771	77	58	35	1·18	474	513
36	66	37	1·61	614	667	78	58	36	1·21	540	523
37	65	38	1·61	717	667	79	57	36	1·17	510	509
38	68	37	1·71	734	703	80	54	36	1·05	422	466
39	66	39	1·70	769	699	81	61	37	1·38	514	584
40	63	39	1·55	690	645	82	59	35	1·22	588	527
41	70	40	1·96	745	792	Sums	—	—	135·84	56,064	—
42	54	33	0·96	441	434	Means	—	—	1·657	683·7	—

* It is of interest to note a slight tendency of the plotted data to follow a typical growth curve where the linear regression tended to overestimate for the young animals and underestimate for the more mature beasts. A third degree curve was calculated but was not found to give a significant improvement in fit.

CORRESPONDENCE

The Editor, East African Agricultural Journal

DEAR SIR,

The accompanying rough sketches show the method of making a form for the casting of semi-circular concrete flumes for lining an irrigation furrow. The materials for one mould are as follows:—

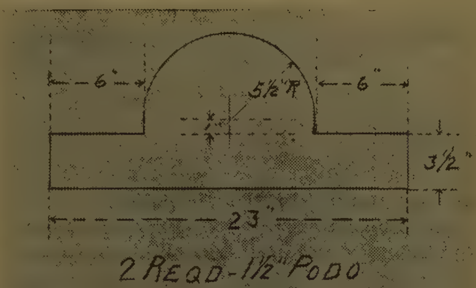
- 4 pieces Podo 10″ × 1½″ × 23″.
- 2 pieces Podo 4″ × 1″ × 2′ 6″.
- 2 pieces Podo 6″ × 1″ × 2′ 6″.
- 1 piece G.I. Sheet 18″ × 24″.
- 1 piece G.I. Sheet 24″ × 24″.
- 2″ screws and small nails.

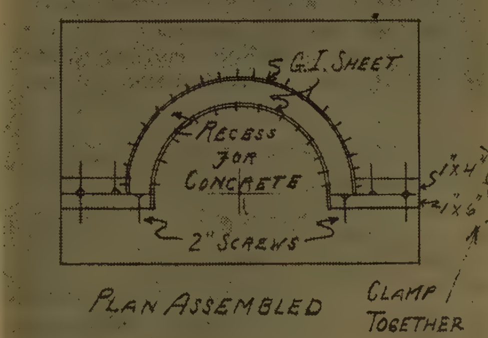
The finished flumes are 11″ I.D., and 2′ long. A 1 : 3 : 5 mixture is used, rather wet, to facilitate tamping. The moulds are, of course, filled standing on end. The cast is allowed to stand two days in the moulds before stripping, and then a further two days *in situ* before being moved. No reinforcing is necessary. Use plenty of old engine oil for greasing the halves of the mould before assembling. Costs are about 80 cents per linear foot, i.e. Sh. 1/60 per section. This includes cement at Sh. 12/50 per bag, sand at Sh. 16 per ton, and the wages of two men. Fourteen moulds are used, and two men will break the necessary stone, strip and fill seven moulds in four hours. I have just completed the lining of some 1,500 feet of furrow, and total costs, laid in place, do not exceed Sh. 1 per foot. Of course the flumes should be allowed to season a month or two before being laid. The joints are made with 1 : 3 cement mortar.

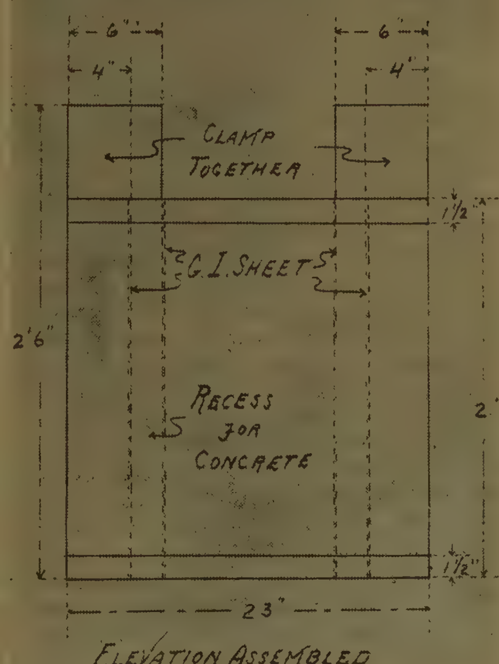
Yours faithfully,

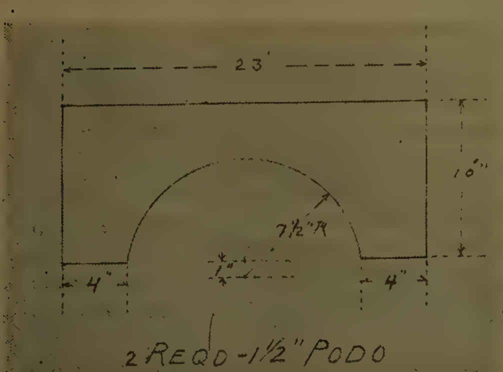
PLATEAU, KENYA, W. L. JACKSON.

6th August, 1950.









THE ROOT SYSTEMS OF SOME BRITISH SOMALILAND PLANTS—I

By P. E. Glover

(*Received for publication on* 3*rd August*, 1950)

Introduction

I decided when I arrived in British Somaliland, that in order to carry out a pasture survey it was necessary to have a good knowledge of the root habits of some of the more important plants, and to find out to what extent their roots were adapted to local climate and edaphic factors and how they were being influenced by overgrazing, trampling and consequent soil desiccation and erosion.

J. B. Gillett (1941) recognized the significance of root systems and made many interesting observations upon them. On the whole, it would seem that his observations are borne out by the results recorded in this paper.

Geographical Position of British Somaliland.

British Somaliland lies between latitudes 8° N. and 11° 30′ N. and between longitudes 42° 41′ E. and 49° E. It is a small country (area approximately 68,000 square miles) but difficult of access, with its coast line along the southern shores of the Gulf of Aden and wedged between French Somaliland and Abyssinia in the west and Italian Somaliland in the east and south.

Topography.

The land rises in steps through the coastal plain or guban to a steep escarpment edge called the Golis Range, which runs roughly parallel to the coast. Altitudes up to 6,500 feet are reached in Western Somaliland, and 7,000 feet or more in Eastern Somaliland. The Golis Range is the main watershed of the country. Behind it is the great central plateau which slopes gently southwards into the Haud and Somalia.

Climate.

Rainfall.—There are no consistent rainfall records earlier than 1923 and such records as do exist are admittedly scant. The natives have many legends and stories about the great floods and droughts of the past century, but it is not possible to date any of these periods accurately. According to Farquharson, 1926 was a year of very heavy rainfall as is shown in the following table for Hargeisa.

Year	1923	1924	1925	1926	1927	1928
Rainfall in inches	16.86	18.06	16.59	31.91	14.58	12.15

Year	1929
Rainfall in inches	17.06

The average annual rainfall (Hunt, 1945) between 1929 and 1939 for places which correlate closely with the sites from which roots were examined was:—

Hargeisa on the Inland Plateau, 60 miles west of Gan Libah and 5 miles west of Haleya: 17.8 inches. Sheikh on the Golis Range, 28 miles east of Gan Libah: 19.25 inches. Manjasseh on the foothills in the Guban, 15 miles WNW. of Ged Dobo: 5.49 inches, for 1944 only. (No average available.) Berbera on the coast, 25 miles NNW. of Bed Dobo: 2.15 inches. Burao on the Inland Plateau, 20 miles ESE. of Jerin: 8.10 inches. Danot in the Haud, 40 miles S.E. of Alablah: 6.61 inches, for 1944 only.

(All the above distances are approximate and as the crow flies and not by road.)

British Somaliland has two main rainy seasons known as the "Gu" from May to August and "Dair" from the end of September to the end of November. The dry periods between are known as "Haga" and "Jilal", but there are two minor rainy periods in between them. In some places in the Golis Range, like Gan Libah, and at Hargeisa the rainfall may be remarkably evenly distributed over six months of the year (e.g. Farquharson, 1929).

	Inches
April	3.57
May	2.64
June	2.54
July	2.33
August	2.21
September	2.98

Temperatures.—There is quite an appreciable annual range of temperature in most parts of the country, but altitude also exercises a considerable influence. According to Gillett (1941) the absolute annual shade maxima for places on the coast range between 41° C. and 49° C., and the minima from 10° C. to 16° C. For places on the Plateau the

absolute annual temperature maxima range from 31° C. at Erigavo, to 35° C. at Burao, and the minima range from 2° C. at Erigavo to 17° C. at Burao.

Soils.

G. H. Gethin-Jones (1942) who analysed some soil samples collected by Mr. D. C. Edwards from British Somaliland wrote: "These soil samples are interesting in that they represent well-recognized desert soil types".

His observations on a sample from the Haud were:—

"*Sample I.*—From 10 miles East of Bohotleh in the Haud.

The top-soil (0″-8″) and subsoil (8″-16″) represent a typical red sand. It is a loamy sand composed mainly of coarse and fine silica sand stained with iron oxide. On treatment with acid the coating is easily removed leaving a rounded white sand. Similarly, the small amount of ferruginous clay is readily discoloured by acid treatment giving a filtrate that is rich in dissolved iron. These red sands, sampled to a depth of 16″, do not in themselves indicate a relatively fertile desert soil. It is likely that the good type of grass-bush vegetation obtaining on this soil owes its origin to a less sandy soil at a lower depth and possibly including a heavier moisture-retentive reddish clay loam, if this is a sedentary soil derived from limestone. Such a heavier soil, under a mulch of a sandy surface soil, would be chemically rich and would have a high water-holding capacity for maintaining growth over prolonged dry periods. It would be interesting to know if such a heavier lower subsoil exists, and if so, whether grass and bush roots depend mainly on this horizon for vigorous growth."

Further, in connexion with the Haud soils, he wrote:—

"*Sample II.*—From just off Haud Plain to N.E.

The surface soil (0″-4″) represents a reddish-brown calcareous clay loam which passes into a highly calcareous, stony and gritty clay loam (4″-10″). The stones and grit which are composed of hard limestone except for a single fragment of chert in the subsoil, amount to 2.4 per cent for surface soil and 29 per cent for the subsoil, and it is likely that at greater depths the soil would be mainly of such limestone with some of the reddish clay loam. This soil profile is likely to represent a truncated red desert sand or else the covering of red sand has not been allowed to form owing to erosion about keeping pace with mature soil formation. The reddish-brown clay loam would then be similar to the heavier subsoil stipulated for soil Sample I. If soil II occurs on sloping land off soil I, and if limestone underlies both, then this explanation is still more likely. Sample II, with so much limestone at 10″, suggests a shallow phase of this soil type and, without the covering of red sand, the soil would dry up rapidly and would be expected to carry a poor type of vegetation. The shallow (0″-4″) surface soil has the most nutrients of the soil examined. It is high in phosphates and potash and contains 0.087 per cent of total nitrogen, thus indicating about four times the organic matter content of Sample 1."

During the period September to December, 1945, a fairly detailed survey of the Haud was carried out, and the root-systems of a number of plants were examined at Alablah (45° 1′ 30″ E., 8° 2′ N., 2,500 feet altitude) and at Hria Hede, ten miles east of Duruksi.

It was found that Mr. Gethin-Jones had been right in his surmise that heavier less sandy soil might exist at lower levels. At depths ranging from one to two and a half feet the soil almost invariably graded down to a hard dark red clayey type which was too hard for the roots to penetrate easily. Also this was the case even in the "dohos" (depressions where the water collects during the rains). Though in the "dohos" the surface soil was grey in colour, much more clayey than the red soil and profusely cracked, it too merged into a very hard dark brown "pan" at depths of two to three feet.

Another interesting point about Haud soils was the fact that in a number of cases a hard limestone layer was struck at depths varying from 18 inches to 3 feet. This shallowness was evident in many parts. On the other hand Macfadyen (1933), in a discussion on the Haud soils writes: "The thickness appears to vary considerably. From a locality near Dudwein, some 80 km. SE. of Hargeisa, Parkinson (1922) records a thickness of about 34 m."

An interesting point about the Haud soils is the very frequent occurrence of tall termitaria on them. Devastation, though serious here is not yet as serious as in other parts of the country and this could be attributed in part at any rate to a higher soil fertility and a consequently more luxuriant vegetation. Vageler (1930) writes:—

"In very many districts and particularly in the grey earth district of Africa, native cultivation is very noticeably restricted to red-earth areas rich in termitaria, and indeed, the broken-down nests are also used in spite of the danger that termites will attack the crop. The reason for this choice lies in the physical properties of the red earths, which make them attractive to the natives and also in the fact that these termite infested red earths are for the most part considerably richer in plant foods than the surrounding grey soil."

D. C. Edwards (1942), when discussing the soils of the Haud, writes:—

"The whole region is known to the Somali tribesmen as the 'Haud' and the name conveys to them a particular soil and vegetation. On several occasions in the course of the survey, careful observations were

made of the change from superior to poorer vegetation in passing from the red soil of the Haud to other types."

It is true that superficial observation does give the impression that in the Haud the vegetation is more luxuriant than in other parts, but vegetation analyses do not support this theory. The average basal plant cover, using the 0.25-metre list quadrat method (West, 1937), for different parts of the Haud is only 4.05 per cent, which is not as high as that of many other places. For instance, in the Ain valley at Wadamago, the basal cover was 15.3 per cent; on the Arorih Plain 4.46 per cent; on the Jigjiga Plain between Borama and Jigjiga 35.4 per cent; at Gan Libah 5.4 per cent; in the trampled salt areas of Zeilah 10 per cent and the salt grass region at Bulhar up to 44.02 per cent. Many of the plants in the Haud are drought resistant and semi-succulent (e.g. *Commiphora* spp. which are not grazed and cut severely by the local inhabitants). Also as water is very scarce during the dry seasons the whole region is not relentlessly grazed throughout the year, as is the case further north.

It may be likely that the "Haud" vegetation tpye is more truly governed by altitude and rainfall than purely by the soil. This is borne out by the fact that a similar Haud type of vegetation occurs at the same altitudes as the Haud proper, when one descends into the Guban in the foothills of the Gollis Range (Gillett, 1941).

In the coastal region or Guban where much of the soil eroded from the plateau and escarpment is deposited, great depths of soil exist in many places.

With regard to the Zeilah Plain, Macfadyen (1938), writes:—

"The material is mainly alluvial, brown to grey in colour, and varies considerably from fine clayey soils, and pebbly hill-wash with boulders. It is sometimes of considerable thickness, Parkinson having recently recorded that it reached 90 m. in a bore penetrating it at Zeilah.

Dune sands are found along the immediate coastal belt between Zeilah and Bulhar, and again somewhat inland E. and SE. of Berbera. In the Zeilah-Bulhar district, they are of normal yellow colour, but east of about 45° 15′ E., the sands are reddish, owing to their origin in part at least, from the exposed Nubian Sandstone.

On the sea-shore between Berbera and Zeilah are observed extensive stretches of heavy mineral sands. They are mainly black owing to concentration of the large iron ore content by the waves or more rarely red, owing to concentration of garnets."

However, beyond an analysis of the black sands made by G. H. Tipper for Dr. Macfadyn, six analyses made by Mr. Gethin-Jones for Mr. D. C. Edwards and a few analyses quoted by Gillett, nothing is known about the physical and chemical composition of Somaliland soils.

Notes and profiles were made for every site on which a root system was studied.

The roots of several plants were examined at Jerin (45° 21′ 30″ E., 9° 30′ N. and altitude 3,860 feet) near Burao and as they were in a similar soil type to that described in a further analysis made by Mr. Gethin-Jones, the following extract might be relevant:—

"*Sample VI.*—From about 18 miles S. of Burao in *Acacia-short grass open woodland.*

The soil sample taken to 16″ represents a reddish brown, slightly calcareous loamy sand, which in nature is about intermediate between Sample I and Sample II. The coarse fraction is mainly silica coated with iron oxide, but less pronounced than Sample I and the clayey fraction and the free calcium carbonate content link it with Sample II. Perhaps it is a less mature soil on the way to becoming a red desert sand. The soil has very poor cohesion and is liable to water and wind reassortment, resulting in the formation of a still lighter-textured surface soil."

Hunt (1945) constructed a soil map of British Somaliland, based on the geology and by mapping certain "fastidious" plants. He writes:—

"The whole country is more or less calcareous, most of the soil containing lime and much of it with hard calcareous 'Kankar' (doubtless the Karkar Macfadyen (1933) or the Kurkar of the Middle East Picard (1943), and Eig (1927), is meant) or secondary limestone forming a hard surface to slopes and filling joints and cracks in the rocks.

The main division of the country, obvious from a glance at the soil map (III VIII), is between the area N. and E. of the continuation SW. shore of the old Tertiary Red Sea and the area to the S. and W. of this line, which roughly extends from Bulhar (10° 23′ N., 44° 25′ E.) to Kirit 8° 58′ N. 40° 09′ E.).

NE. of this old coast line the soil is calcareous, but mostly gypseous and often saline. SW. of the old coast the country is more arenaceous, owing to outcrops of sandstones and granitic rocks, not so predominantly calcareous, and not gypseous $CaSO_4$ (Anhydrite).

The south-western arenaceous, non-gypseous area appears to be the better agricultural soil as it is less liable to become mineralized or 'cracked'.

The only other important variation is the soil derived from volcanic rocks, especially on the Zeila Plain and around Bulhar.

It is suspected that this volcanic soil is especially fertile when sufficiently watered."

On the Plateau, especially nearer the escarpment, soil erosion due to overstocking and tree destruction has become a very serious

menace. One of the most striking features of the ghastly "forests" of dead trees to be found in many parts of the country is the fact that in almost every instance the roots of the dead trees stand out well above the present level of the soil. Often the soil has been eroded down to rock level.

The top-soil in many parts has long since been taken away by the action of wind and water. Wayland and Brassnett (1938) in a report on soil erosion and water supplies in Uganda write:—

"The top-soil contains most of the organic colloidal material with which is associated all the biological activities and the granular structure of a fertile soil. On the removal of the natural vegetation of a field on any degree of slope the fine soil fractions are dissociated from the crumbs by pounding of the rain; some to be carried into the soil mass and block the capillaries to form an impacted layer, the remainder to set off down the slope. Structure is gradually destroyed and the soil is left to the mercy of wind and water."

Classical examples of this process can be seen on the devastated forest areas of Gan Libah, Waggar and Libah Hele in the Borama districts; as well as the eroded dead tree areas bordering the Arorih Plain and at Haleya in the Hargeisa District. It would appear that Brassnett's remarks may be relevant in explaining, in part at least, why roots are found exposed for 2 to 3 feet above the present soil level in flatter areas where gully erosion is not always evident.

Because of the greater solubility of phosphoric acid, etc., in overheated rapidly dried soils, it follows that as devastation progresses an increasing amount of soil on the Plateau (where there is severe gully erosion), is being impoverished by leaching as well.

In the flatter areas such as the Haud, however, although wind and sheet erosion are severe, the leaching takes a different form and, instead of carrying these minerals right away, rain-water percolating through the soil dissolves them from the upper layers and deposits them lower down and tends to form a "pan" of harder and heavier soil. According to Russell (1932) "Under arid conditions, percolating rain-water plays but litttle part in soil formation, its main action being simply to leach soluble salts from the surface to lower horizons. The primary processes are now the mechanical disintegration by frost and wind and the mechanical transport of these disintegrated fragments by wind and water erosion".

In the process of examining roots it was noticed that in the Haud and many other parts of the Inland Plateau, even if the soil was sandy and friable on the surface it usually became very hard at depths varying from 1 foot to 3 feet. It was found that even in sandy soils such as those in parts of the Guban and the Haud, the visible percolation depth of rain-water into the soil after as much as 1 inch of rain had fallen, varied according to the texture of the soil surface and seldom exceeded 2½ feet. The greatest percolation depths were immediately beneath, or in the vicinity of plants on the surface.

One of the most striking features of the roots of many Somaliland plants is their tendency towards shallow but extensive lateral development, which is what would be expected in view of the soil phenomena discussed above and would appear to be an obvious adaptation of plants growing in desert soils (Weaver and Clements, 1927). However, in a country such as this where devastation of the vegetation is progressing at a great pace, extensive shallow lateral root development is a serious disadvantage to plants in exposed and eroded sites.

Soil Temperatures.

Russell (1932), says:—

"When a soil is dried out and warmed at the same time, as in summer, changes occur which cannot yet be satisfactorily explained, nor is the relative importance of temperature and of drying yet known.

(1) The solubility of the phosphoric acid, inorganic electrolytes, and organic matter is increased both on drying the soil at room temperature and on heating a damp soil.

(2) The nitrate content tends to decrease on drying or heating. The magnitude of these effects depends on the soil type."

In a country like British Somaliland where the soil is being denuded of plants at an appalling rate, it means that new expanses of soil which were formerly protected by plants are being continually exposed to overheating and rapid desiccation in the process of destruction by man and his stock. Therefore the significance of the chemical changes as outlined by Russell cannot be over-emphasized in denuded arid areas.

At Jerin a study of the soil temperatures was made on the surface (thermometer just covered by a thin film of soil), and at depths of 1 inch, 1 foot and 2 feet, in an open denuded area. Readings were taken every hour during the daylight period of the 10th and 11th

of September, 1945. Unfortunately the thermometers were only graduated up to 50° C., and all temperature readings above that were approximate.

It will be seen from the accompanying graphs (Diagram 1) that the temperature of the soil just below the surface at midday was very high indeed and there was a surface range from 19.6° C. to 56.9° C., and back to 27.5° C. for the average of the two sets of daily readings between the hours of 6 a.m. and 6 p.m. The two highest readings recorded were 65° C. at 12 noon on 10th September, 1945, and 60° C. at 2 p.m. on 11th September, 1945. (The stems of all the thermometers used were insulated inside a wooden tube lined with cotton wool.)

Method of Studying Root Systems.

The method adopted in studying the root systems of the plants discussed in the text was:—

(1) To select a site representative of a definite vegetation type.

(2) To choose a certain number of dominant plants within the community and to dig an oblong pit about three inches away from the base of the plant and of a width and depth great enough to allow for the study of the whole root system.

(3) The face of the pit nearest the plant was carefully smoothed away with a flat-backed spade until it was flush with the base of the plant. In the case of large tussock grasses the face was cut away for an inch or two into the tussock.

(4) After this a 10 cm. lattice grid was made on the smoothed surface by driving small wooden or wire pegs into the wall at the requisite intervals and lacing thin strings across them.

(5) Small amounts of soil were dug away very carefully with a sharp-pointed instrument from the base of the plant, working downwards until several of the larger roots immediately at the stem junctions had become partly exposed.

(6) When this had been done each root and all its rootlets was carefully traced from square to square with a fine needle and a very fine, gentle spray of water from a spray pump.

(7) As the work progressed from square to square the roots were drawn to scale on a chart. The method was used by Weaver and Clements (1927) and Murray and Glover (1936).

(8) Wherever possible the roots were photographed.

In the case of some of the larger shrubs and trees with very widely spread shallow lateral root systems, it was not possible to use the above method. A surface dissection of the roots was made instead. A technique used here was to scratch away the surface soil around the base of the plant until the first roots were partly exposed and then to trace and chart each one in turn along its entire length. The object in this case was to study and to depict the lateral roots in a horizontal plane in contrast to the vertical plane of the bisect method. The surface plans of the shallow lateral roots are of particular significance in the light of the foregoing discussion on erosion and soil deterioration under hot arid conditions.

THE ROOT SYSTEMS

In order to facilitate description, the plants whose roots were examined have been divided into groups:—

Group I.—Succulents.
Group II.—Grasses.
Group III.—Forbs.
Group IV.—Shrubs including some with tuberous underground roots.
Group V.—Trees.
Group VI.—A 17-metre composite trench bisect.

The Vegetation Types

The vegetation types in which roots were studied were:—

Acacia etbaica transition open woodland and plateau grass.

Acacia bussei open woodland and plateau grass.

Haud—Commiphora—Acacia tree shrub and grass.

Haud sub-type *Acacia* tree and shrub.

Balanites and *Mœrua* coastal shrub *Acacia*, grass and desert shrub.

Group I.—Succulents

Adenium somalense Balf.f. var. *crispum* Chiov. Vernacular "Badiawen". (Diagram 2.)

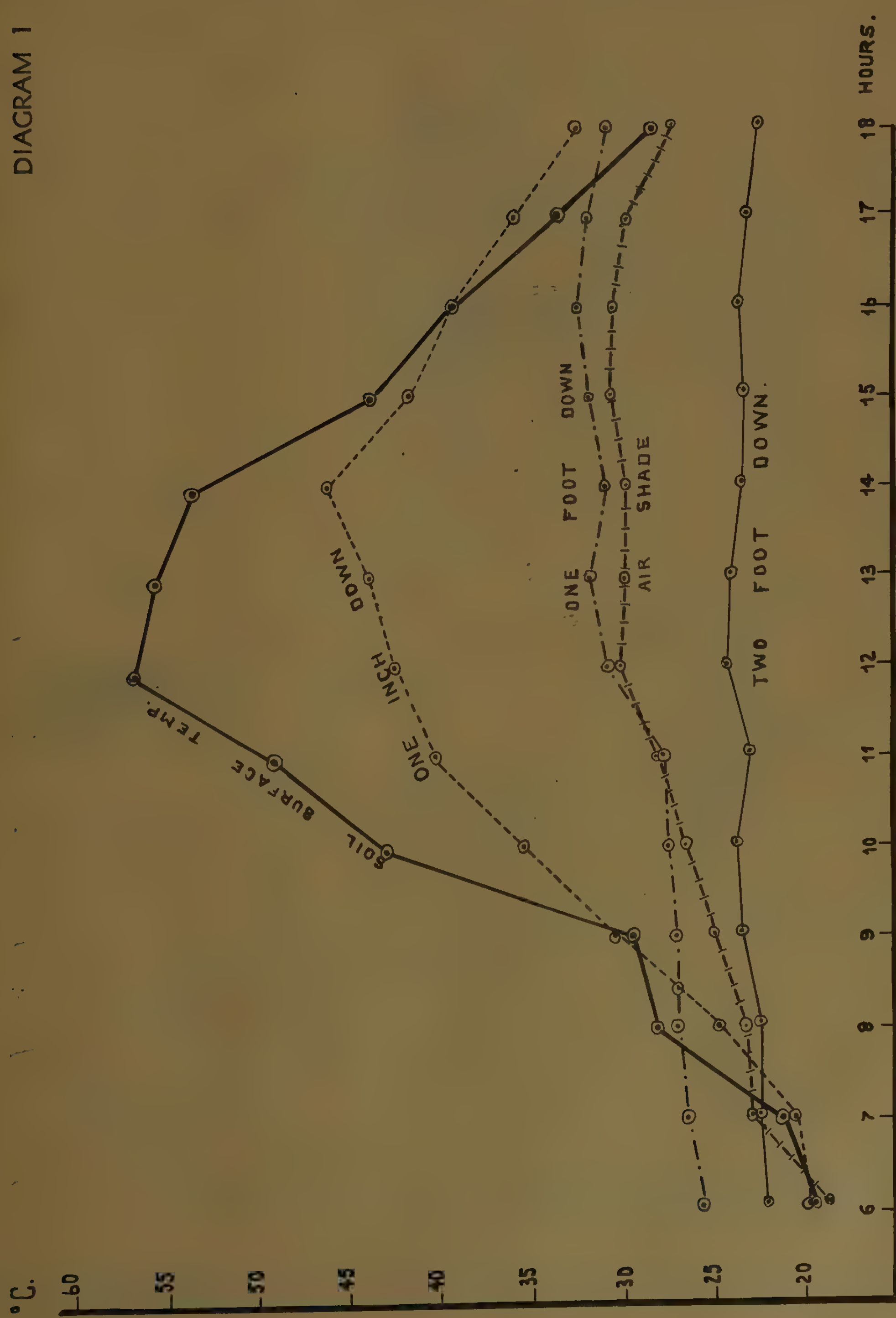
Vegetation type.—*Haud* sub-type *Acacia* tree and shrub.

Locality.—Guban Ged Dobo.—
Latitude 10° 7′ 30″ N. (approx.).
Longitude 45° 12′ 30″ E. (approx.).
Altitude 1,900 feet.

Annual rainfall.—Probably 8 to 10 inches (Hunt, 1945).

Adenium somalense var. *crispum* Chiov. occurs in many parts of Somaliland but most frequently in the Guban. It has thick gnarled branches with terminal whorls of long narrow leaves up to 13 cm. long and 1.5 cm. wide. It may reach a height above ground of 50 cm. or more. When damaged it exudes a viscid, transparent, slightly reddish, mucilaginous sap. The underground parts consist of a large "com-

DIAGRAM 1



TWO-DAY AVERAGE. SOIL TEMPERATURES. JERIN. 10-9-45 to 11-9-45

ADENIUM SOMALENSE HALL F. VAR CRISPUM CHIOV. "BADIAWEN" DIAGRAM 2

GED DOBO, LOWER SHEIKH, 13TH MAY 1945

FIG. 1.—Root bisect and soil profile.

FIG. 2.—Main tuberous roots after fibrous roots removed—note upward trend of some roots.

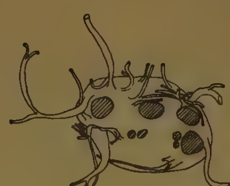


FIG. 3.—Surface view of main tuber showing clockwise rotation of secondary tubers.

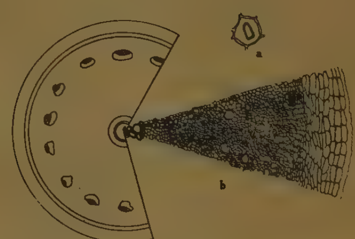


FIG. 4.—Diagrammatic T.S. fibrous root near tip. (*a*) Latex cell enlarged; (*b*) Detailed wedge of Fig. 4.

FIG. 6.—Showing a main lateral growing upwards into mound of dubera glabra A. Dc.

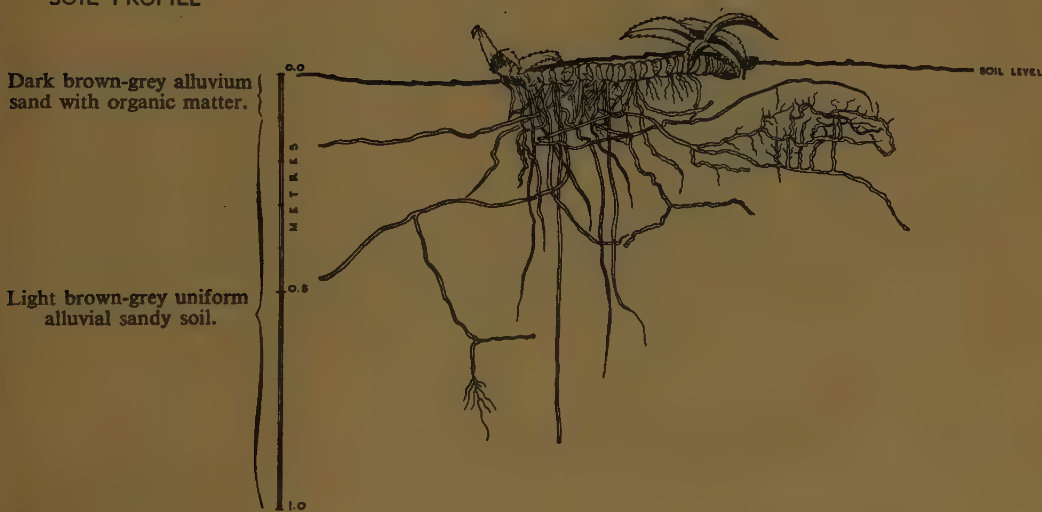
FIG. 5.—Showing detail of one surface lateral in the mound.

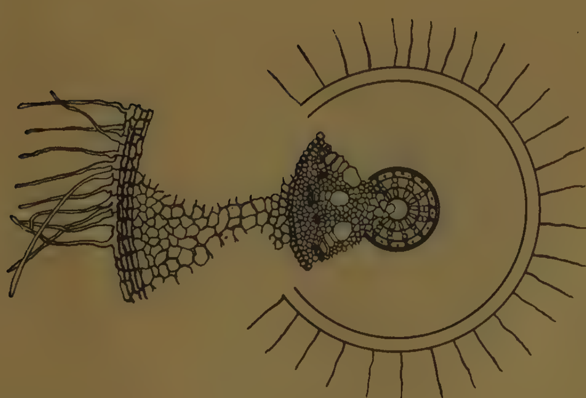
ALOE SP. "DAAR"

DIAGRAM 3

HALEYA, 17TH DECEMBER 1945

SOIL PROFILE





Diagrammatic T.S. near root tip with L.P. detailed section

NOTE.—Felt of root hairs invisible with naked eye or hand lens unless washed clean.

DIAGRAM 4

CARALLUMA SP. "UDAPTEIS"

GED DOBO, 12TH MAY 1945

FIG. 1.—Root bisect and soil profile.

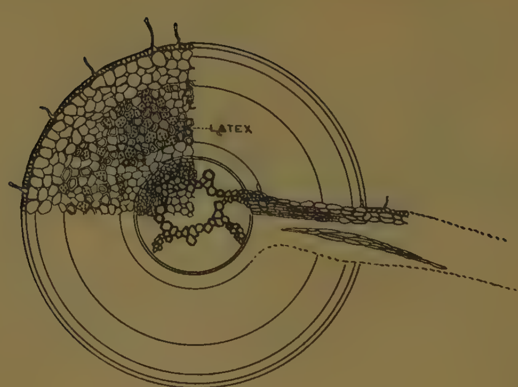


FIG. 2.—Semi-diagrammatic T.S. section of young root near tip showing: (*a*) Plan; (*b*) Detailed Section.

ROOT SYSTEM OF EUPHORBIA SP. "DIBU"

DIAGRAM 5

GUBAN

GED DOBO, LOWER SHEIKH, 24TH MAY 1945

SOIL PROFILE B

Fine dark grey sand.

Coarse white gravelly sand, grains up to 3 m.m. in diameter

Pockets of water-worn pebbles and sharp smale stones.

Coarse grey gravelly sand.

Fairly fine grey gravelly sand very little organic matter.

FIG. 1.—Root bisect showing fine and main roots in one plane Scale 1 : 30.

FIG. 4.—Bodies in latex in root.

FIG. 3.—Plan of main thick surface roots. Scale 1 : 30.

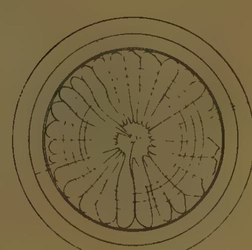


FIG. 5.—Diagrammatic T.S. of young root.

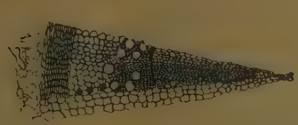


FIG. 6.—Detailed section of Fig. 5.

SOIL PROFILE A

Fine sand

Micaceous sand

Coarse sand.

Pebbles in fine gravel.

Dark grey finer sand with pebbles.

FIG. 2.—Root bisect showing main thick roots with fine roots removed. Note roots shown in dotted lines which grow up above point of origin behind the main stem. Scale 1 : 30.

DIAGRAM 6

SANSEVIERIA SP. "HIG"

GED DOBO, LOWER SHEIKH, 20TH MAY 1945

FIG. 1.—Root bisect and soil profile.

FIG. 2.—Semi-diagrammatic T.S. of young root showing detailed section.

pound" tuberous taproot with a highly complicated lateral root system. (*See* Diagram 2, Figure 1.)

A specimen of this plant was examined at Ged Dobo in May, 1945. It had numerous thick gnarled branches above ground up to a height of 45 cm. The root system was studied in the vertical and horizontal planes by the methods described.

In the vertical plane the roots reached an overall lateral development of 3.4 metres and a depth of 1.4 metres. The underground parts included a large tuber which was a "compound" swollen taproot, 50 cm. in diameter at its widest point. (Diagram 2, Figure 2.) The top from which sprung the gnarled branches was just at ground level. Fifty cm. down the main tuber divided up into two main thick tuberous roots 10 cm. or more in diameter at the point of origin. One root which had developed laterally had a large branch root over 3 cm. in thickness at its point of origin. Except for the one thick lateral, all the big tuberous roots continued straight down to end abruptly in numbers of short fibrous rootlets.

The lateral roots were divided into three zones from their junctions with the main tuber to their growing tips. A thick tuberous zone passed into thinner fibrous elongated roots, which in turn broke up into fine rootlets. There were very few root hairs and the "tomentum" common at the growing tip of other types of roots, was not present.

Reference to Diagram 2, Figure 1, shows that the zone of greatest lateral root development was from the soil surface down to about 20 cm. The next zone of lateral root development was between 40 and 70 cm. down. In this zone numerous small white snail shells were observed in the soil. The roots were a bright brown colour on the outside, except at the growing points which were white. They were tough and fibrous inside and contained a similar viscid quick-drying "sap" to that found in the leaves and stems. The rootlets were short and tapered suddenly.

Microscopically the main tuber was made up of an outer bark about 6 mm. thick, with fibres and pulp inside it. When it was first examined, there had been no rain for several months. It was soft to the touch and had shrunk away from the soil around it leaving a gap 2½ cm. wide. A few hours after half an inch of rain had fallen it had become hard to the touch, and had completely filled the gap again. The main lateral roots showed a distinctive growth form. The clockwise rotation of roots around the main tuber (*see* Diagram 2, Figure 3) was also found in many other plants which were examined.

Another interesting point about this plant was that many of the roots showed a definite anti-geotropic habit and grew upwards, some of them straight up out of the main tuber. There was a network of fine roots around the main tuber just below the soil surface and some of the lateral roots had wound themselves right around it. Immediately above the main tuber and beneath the "crown influence zone" of the aerial parts numbers of rootlets grew up to within 2 mm. of the soil surface.

Diagram 2, Figure 5, shows a horizontal dissection of a lateral root 3 metres in length, which grew upwards from the main tuber and ramified through some small sand mounds around clumps of stunted *Dobera glabra* A. DC. There was little development of lateral rootlets until the *Dobera glabra* A. DC. sand mounds were reached, then lateral rootlet development became profuse. Further examination of Diagram 2, Figure 5, shows that this root had grown upwards into the *Dobera glabra* A. DC. sand mound to 45 cm. above its point of origin from the main tuber.

Diagram 2, Figure 4, shows a transverse section across a growing root tip. Figure B shows the cell structure of part of a transverse section of the root tip as seen under the microscope (X 100).

In the cortex there were numbers of thick-walled storage cells filled with mucilaginous sap.

The soil was a typical alluvial sand of the Guban. Its upper layers consisted of a fine-grained grey sand rich in minute mica particles, which passed into a fine grey sand containing fragments of dead and decaying roots and other plant material. The next layer was a medium-fine grey sand rich in mica, but with less dead plant material in it. Another fine-grained layer followed containing dead plant material which in turn gave way to a medium-coarse grey sandy layer with occasional pebbles in it, and then to coarse whitish grey tightly compressed gravelly sand rich in mica particles.

On 12th May, 1945, half an inch of rain fell over a period of half an hour during the afternoon. The next morning, after about one foot of the outer wall had been cut away, it was found that the visible moisture penetration line was 35 cm. down.

The soil profile on Diagram 2, Figure 1, shows that the zones of maximum root activity are in the first 20 cm. and in the medium-fine grained layer, 45 cm. from the surface, probably because there is seldom any very great penetration of moisture into the soil, and because numerous rootlets very near the surface might be able to utilize the moisture from the lightest showers or even dew. The activity in the second zone from 45 cm. down was probably due to the fact that this layer divided the fine-grained soil from the coarse-grained soil, and the presence of dead plant matter within it gave it a higher water retaining capacity than the soil beneath it, thereby making it more suitable for root development.

The habit of anti-geotropic growth of some of the roots and the fact that even large lateral roots may grow upwards into the shelter of sand mounds at the base of other plants would appear to be an adaptation of a desert plant to make the most of every possible source of moisture. It was noticed that after a slight shower or a dew the soil remained moist longer around the stems and beneath trees and other plants, than it did in the open. This anti-geotropic root habit was also noted in Asclepiadaceous plants with underground tubers, especially when the tops of the tubers were several inches below the surface.

Aloe sp. Vernacular "Daar" (Diagram 3).

Vegetation type.—*Acacia etbaica* transition open woodland and plateau grass.

Locality.—Plateau, Haleya, five miles east of Hargeisa on the Hargeisa-Berbera road.
Altitude 4,390 feet (approx.).

Average annual rainfall.—Probably 17.8 inches (Hunt, 1945).

The abundance of *Aloes* is one of the most striking features of *Acacia etbaica* transition open woodland and plateau grass vegetation. For this reason it was thought worth while to study the root habits of an *Aloe*.

The plant examined was 15 cm. high with a fleshy horizontal rhizome 45 cm. long and 5 cm. in diameter, lying just below the surface of the soil. A whorl of thick fleshy leaves up to 15 cm. long and 5 cm. wide, with hard-toothed edges grew dorsiventrally from each end. There were numerous nodes along the rhizome with old bits of leaf sheath still adhering to their upper part, and groups of stringy roots growing downwards from the under surface of the nodes. The old roots were hard, stringy, and dark brown to black in colour. The young growing tips were shiny, smooth and cream-coloured, sometimes tinged a "curry" yellow. There were very few rootlets off the main roots, but sometimes there was a bunch near the tips. The zone of greatest root activity was from just beneath the surface down to a depth of 40 cm. No root hairs were visible to the naked eye. The roots reached an overall lateral spread of 1.2 metres and a depth of 65 cm. The transverse section of the root tip showed an ordinary Liliaceous root whose long root hairs adhered so closely to the soil that they were invisible until the root had been well washed and the hairs had been freed. This character may in part explain the hardiness of the *Aloe* in bleak sites.

The soil was uniformly grained light brownish-grey alluvium down to a depth of one metre. From the surface down to about eight cm. it was darker due to the fact that it contained a higher percentage of organic matter.

This *Aloe* obviously uses its rhizomes and leaves as storage organs. Under normal conditions concentrations of *Aloes* are usually found in the protection of thickets of larger plants and trees but they are particularly resistant to trampling, desiccation and erosion, and often survive in almost pure "stands" when most of the other plants have been killed off. This is doubtless due to the fact that in proportion to the aerial parts the roots are so poorly developed that they are not directly damaged by trampling and devastation and also because the leaves and other parts are not grazed by stock, nor put to any extensive use by man owing to their extreme bitterness.

Sometimes the young leaves are eaten by baboons or man, but only when driven to it by extremity. Locust hoppers eat the soft inner parts of damaged leaves. The leaves of some species of *Aloe* are sometimes used medicinally, and the roots for dyes.

Caralluma sp. Vernacular "Udapteis" (Diagram 4).

Vegetation type.—*Haud* sub-type, *Acacia* tree and shrub.

Locality.—Guban; Ged Dobo.—
Latitude 10° 7′ 30″ N. (approx.).
Longitude 45° 12′ 30″ E. (approx.).
Altitude 1,900 feet.

Annual rainfall.—Probably 8 to 10 inches (Hunt, 1945).

Caralluma sp. is widely spread throughout the country, but is particularly frequent in

parts of the Guban. Its aerial parts are made up of one, or a cluster of thick rectangular leafless stems with slightly toothed edges. It may reach a height of one metre.

The plant whose root system was examined at Ged Dobo was 35 cm. high and the thickness of its branches varied from three to five cm. It was growing in the open in fairly even grey sandy micaceous alluvium with a small sand mound at the base of it. From the surface down to about eight cm. the soil was slightly darker due to the presence of a certain amount of organic matter. From 8 to 50 cm. it was homogenously fine-grained, grey, and the roots extended down to a depth of 50 cm. Their lateral development was 50 cm. on one side and 1.2 metres on the other side (i.e. an overall lateral development of 1.70 metres). The first 45 cm. of soil was the zone of greatest root activity. The thick succulent main roots ended abruptly in short whitish-coloured fibrous rootlets.

The root tips were covered in a "brush" of stout root hairs clearly visible to the naked eye. (A transverse section of a root tip examined under the microscope at a magnification of 100 diameters is illustrated in Diagram 3, Figure 2.) This species of *Caralluma* usually begins its growth in the protection of other plants but, because of its succulent habit and the fact that it is not eaten by stock or used by the Somalis, it survives after other plants have been killed out.

Euphorbia sp. Vernacular "Dibu" (Diagram 5).

Vegetation type.—*Haud* sub-type, *Acacia* tree and shrub.

Locality.—Guban; Ged Dobo.—
Latitude 10° 7′ 30″ N. (approx.).
Longitude 45° 12′ 30″ E. (approx.).
Altitude 1,900 feet.

Annual rainfall.—Probably between 8 and 10 inches (Hunt, 1945).

The species of *Euphorbia* studied here occurs frequently in parts of the Guban. The specimen examined was 80 cm. high and branched freely from ground level. The branches averaged 3 cm. in diameter, were square in cross-section and had clusters of thorns at regular intervals along their edges. When damaged a quantity of thick white latex oozed from the wound.

There was a low sand mound at the base of the plant. The overall lateral extent of the roots was 2.7 metres and their maximum penetration was 70 cm. (Diagram 5, Figure 1). Just below the soil level was a thick root stock 10 cm. in diameter and 12 cm. long, from which sprung a number of stout main roots. (Diagram 5, Figure 2, enlarged × 1½ on Figure 1.)

The root system of this plant had many similar characteristics to that of *Caralluma* sp. (*See* Diagram 5, Figure 1, and Diagram 5, Figures 5 and 6, showing a transverse section of the root tip magnified × 100.)

The small roots and rootlets branched off abruptly and did not penetrate far into the soil. A number of fibrous rootlets clustered around the base of the plant just below ground level within its "crown influence zone".

The usual clockwise rotation habit of the main roots was evident, but there was an anti-clockwise twist towards the ends (*see* horizontal dissection Diagram 5, Figure 3). The zone of greatest root activity was from just below the surface down to 50 cm. The growing root tips seemed to bulge out and then end in a short sharp point. There were very few root hairs.

The first 15 cm. of soil consisted of fine micaceous dark grey alluvial sand fairly rich in organic matter. This gave place to a coarse whitish gravelly sand with grains up to 3 mm. in diameter which continued to a depth of 50 cm. From 50 to 55 cm. down there was a layer of fairly large water-worn pebbles which gave place to a coarse grey gravelly sand down to 65 cm. The next layer consisted of a fine, grey, gravelly sand containing a certain amount of organic matter. Particles of mica were abundant throughout the soil.

Diagram 5, Figure 4, shows bodies seen in the latex taken from a branch of the plant and examined under a high-power lens. The bodies were seen in one slide only and, though a number of other slides of latex were examined, they were not seen again. Latex occurs in the cells of the xylem and in the cortex, mainly in cells which appeared to have thickened walls.

Like *Caralluma* sp. and *Aloe* sp., *Euphorbia* sp. begins its growth in the protection of other plants but, although it is very hardy it does not appear to be as resistant to devastation as *Caralluma* and *Aloes*. Baboons eat the young shoots of this plant but it is not grazed by stock, nor put to any use by the Somalis. The root system of this Euphorbia is very similar to that of *Euphorbia mauritanica* L. and *Euphorbia burmanni* E. Mey. of the Worcester District of the Cape Province of South Africa (Scott and Van Breda, 1939).

Another interesting point about *Euphorbia mauritanica* L. and *Euphorbia burmanni* E. Mey. which the writers seemed to have overlooked, is the fact that they exhibit the same anti-geotropic habit in some of their roots as that so markedly shown in *Adenium somalense* var. *crispum* Chiov. of this country. They also show the same clusters of rootlets near the surface of the soil beneath the "crown influence zone".

Sansevieria ehrenbergii Schweinf. Vernacular "Hig" (Diagram 6).

Vegetation type.—*Haud* sub-type, *Acacia* tree and shrub.

Locality.—Guban; Ged Dobo.—
Latitude 10° 7′ 30″ N. (approx.).
Longitude 45° 12′ 30″ E. (approx.).
Altitude 1,900 feet.

Annual rainfall.—Probably between 8 and 10 inches (Hunt, 1945).

Sansevieria ehrenbergii Schweinf. is locally frequent in parts of the Guban and elsewhere in Somaliland. It has long thick fibrous leaves sometimes up to a metre in length which arise from a stout rhizome varying from 3 to 5 cm. in diameter. Two of the whorls of leaves were on the summit of a slight sand mound and the other two were in a slight horror 30 cm. away at the base of it. A mass of coarse fibrous roots emerged from the junction of the rhizome with the leaves. Other roots emerged singly, or in rows of two or three at the nodes from the ventral surface of the rhizome. They penetrated the soil to a depth of 90 cm. and had an overall lateral extent of 3.3 metres. Several of the large lateral roots penetrated downwards for 30 to 50 cm. and then grew upwards again to within a few millimetres of the soil surface. They were hard and fibrous and a number of them were dead towards the tips. The rootlets were short and stocky and branched dichotomously. The growing root tips were covered with a "brush" of stout root hairs. The zone of maximum root activity was from just below the surface down to about 60 cm.

From the surface to 15 cm. down there was a certain amount of organic matter in the soil. This was a very fine-grained, highly micaceous alluvial sand which continued down to a depth of 30 cm. From there down to 75 cm. it gave place to a layer of coarser-grained micaceous alluvial sand.

Sansevieria, like *Aloe* and *Caralluma*, begins its growth in the protection of other plants. It is resistant to trampling and other forms of devastation, but not quite to the same extent as *Aloes*. The fibres in the leaves are used extensively by the Somalis for making rope.

Diagram 6, Figure 2, shows a transverse section of the growing tip of a root (magnification × 100). It is a typical section of a monocotyledonous root tip with an abundance of stout flask-shaped root hair emerging from the piliferous layer.

Conclusions

From the above diagrams and descriptions the following conclusions may be drawn:—

(1) The zone of greatest root activity for the five succulent plants studied was in the first 50 cm. of soil.

(2) All the plants showed the same anti-geotropic habit to a greater or lesser degree, for they all sent some of their roots upwards to within a few millimetres of the surface of the soil.

(3) The "crown influence zone" of all the plants exerted a direct influence upon the roots, encouraging the formation of clusters of rootlets 2 to 3 cm. below the soil surface immediately beneath it.

(4) The succulent nature of these plants, the adaptation of their roots to desert conditions and the fact that they are not grazed by stock, and are of no extensive economic value to the natives (except *Sansevieria ehrenbergii* Schweinf.) renders them particularly resistant to the effects of grazing, trampling and other types of devastation.

(5) In addition to their succulent aerial parts, all the plants had underground storage organs taking the form of swollen rhizomes in the two monocotyledonous plants studied and tuberous swellings in the roots of the dicotyledonous plants.

(6) The root systems and anatomical root structure of these plants in general, are typical of succulent desert plants common to other desert regions of the world (James, 1936), (Scott and Van Breda, 1939), (Weaver and Clements, 1929).

(7) Reference to the diagrams shows that microscopic sections of the root tips were made in this group only. It was decided that the lack of materials for making permanent slides and the lack of a camera lucida did not warrant continuing the work.

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RECOMMENDED COMMON NAMES FOR PEST CONTROL PRODUCTS

At the beginning of this year, the British Standards Institution made the widespread announcement in the technical and trade press that a Technical Committee had been appointed to devise simple, common names for well-established pest control products (including insecticides, insect repellents, acaricides, nematocides, fungicides, herbicides and rodenticides). The need for common names which do not conflict with proprietary names was pointed out on account of the considerable confusion which has arisen in commercial descriptions and in the technical literature.

The British Standards Institution now announce that this Technical Committee has prepared the first list, containing some 25 common names for the better-known products now in general use in agriculture and in veterinary circles throughout the country. This list is being circulated for technical comment among Government departments, manufacturers and the interested scientific societies before final publication. In order to pre-empt the use of these names as proprietary names, the list has been lodged with, and approved by, H.M. Patent Office. The names will be given protection and will be referred to when application is made for the registration of proprietary names for pest control products.

Wherever possible, the names adopted conform with those already accepted as coined common names by the U.S. Department of Agriculture, and the same system of protection is given by the U.S. Patent Office. It is hoped that the same measures will extend to other countries in due course.

The chemical names assigned to each compound are in accordance with the principles recommended by the Chemical Society. Where possible, only the pure active ingredients have had common names assigned to them, and an endeavour has been made to avoid, with a few outstanding exceptions, the use of initials and numbers. These exceptions are made in the cases of compounds which are already well known by initials, such as DDT and BHC, since a further name would only increase the confusion.

During the drafting, the Technical Committee has maintained liaison with the Commonwealth countries as well as with the appropriate committee in the United States.

CESTRUM AURANTIACUM POISONING

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(*Received for publication on 12th August*, 1950)

During March, 1950, deaths in stock of unknown ætiology were reported from a farm in the Limuru district. Following an investigation by Dr. H. S. Purchase, Mr. W. Luke and the writer the cause of death was found to be *Cestrum aurantiacum* poisoning. Cestrum poisoning was reported for the first time in Kenya in 1948 [1], this is the second recorded occasion. It is now the intention of the Government to schedule *Cestrum aurantiacum* as a noxious weed in those districts where conditions allow for its rapid multiplication and it has escaped from cultivation and spread into grazing areas [2].

In the instance now to be described the cattle had access to the plant in an old deserted garden through which they passed on their way to the pastures. There were numerous young cestrum plants coming up all over the area which had obviously been cropped. The farm had not been stocked for a number of years, cases occurred within ten days of stock being placed on the land and stopped immediately the animals were prevented access to the infested area.

Out of eight animals affected, six died. Four visibly sick animals were treated with adrenalin, two made an uneventful recovery but the other two were hypersensitive the next day, charged on being approached and died later in the day. The symptoms observed in the other four head that died before and during our visit were: listlessness, depression, temperature sub-normal, cessation of rumination and constipation, general weakness, animal would go down and die almost in a coma with agonal paddling movements. The course of the acute fatal condition was from 24 to 48 hours.

The post mortem changes noted were: acute hæmorrhagic gastro-enteritis with hard, dry, burnt-looking fæcal material in the cæcum and colon; marked hyperæmia of brain and meninges; cirrhosis of the liver and chronic nephritis (the liver and kidney changes could not be associated with the acute cestrum poisoning).

It is interesting to note that in these cases although there was a hyperæmia of the brain and meninges, hyperæsthesia followed by a progressive paralysis which was the main symptom described by Purchase [1], was not evident. "Chase Valley Disease" occurring in South Africa, caused by *Cestrum lævigatum* and described by Thorburn [3], follows a similar course, viciousness being a common symptom. The absence of nervous symptoms in four of the cases described above was probably due to the rapid course of the disease.

A diagnosis is made on the symptom syndrome described and the presence of *Cestrum aurantiacum* in the grazing areas.

Differential Diagnosis—

Rabies—Demonstration of negri bodies in brain preparations.

Heartwater—Temperature reaction and demonstration of *Rickettsia ruminantium* in suitable preparations.

Anaplasmosis—Temperature reaction and demonstration of anaplasma in blood smears.

Arsenical poisoning—Chemical analysis of the stomach contents, liver and bone.

As far as the writer is aware there is no known specific antidote hence symptomatic treatment is the only resort.

It is evident from the above that *Cestrum aurantiacum* may provoke serious losses in stock and it is urged that in those districts where the plant is found to be spreading rapidly it be eradicated before it becomes a menace.

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SOIL CONSERVATION AND FOOD PRODUCTION

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Everyone agrees that the loss of topsoil by water and wind erosion is a serious threat to the long-term economic welfare of many parts of the world. But the pros and cons of particular soil conservation techniques and programmes are sometimes somewhat obscured by pseudo-philosophical and even political considerations.

In United States, however, there are two well-defined schools of thought. One school, which may be called the "Moderate", supports voluntary soil conservation, but dislikes any attempt to make soil erosion control compulsory or to require erosion control as a condition of governmental price and other subsidies to agriculture.

The other school (the "Conservationist") stresses the view, which is relatively new in the United States, that men and natural resources are both national assets and must be conserved, e.g. by better social services and better soil conservation. The more far seeing of them seem to feel, in effect, that Americans can no longer expect to achieve production and wealth by metabolizing goods and services which they did not produce, e.g. by using up indigenous soil fertility. Americans, they argue, must "dress and keep the garden" if their children are to enjoy "life, liberty and the pursuit of happiness". Compulsory soil conservation may such people feel, therefore be justified.

The second school of thought, which is closely identified with the United States Soil Conservation Service*, freely quotes the "evidence of history". It tends to argue that the Empires of Babylon, Athens and Rome melted, literally and metaphorically, into dust because they did not practise soil conservation. Apart from the fact that these Conservationists sometimes overlook an equally relevant historical fact, i.e. the gradual desiccation of the Middle East during some thousands of years B.C., they omit, the other side argues, to point out that these ancient empires had no modern science to offset soil erosion by higher crop yields from the use of fertilizers, improved varieties, pest control, etc.

Recently this debate has been enlivened by such books as William Vogt's "The Road to Survival", which points dramatically but not always convincingly to the rate at which world population is increasing on the one hand and the world's soil is being eroded away on the other.

The Technical Debate

In brief, the case against the Conservationists is that it preaches soil conservation too much as a religion and not enough on its own merits as an economic proposition; and, that in some areas, especially in the South of the United States, its policy is technically unsound.

The Conservationist reply is that the United States Soil Conservation Service has made several million farmers conscious of soil erosion and persuaded hundreds of thousands of them to do something about it; that its technical propaganda was and is necessary to stir up farming opinion and create public interest in conserving national resources; that the technical validity of its policy is amply confirmed by the higher yields on farms which have adopted proper soil conservation measures.

This last claim is at least partially disputed by the Moderates and, as the tendency of some governments and individuals to regard the opinions of the Conservationists as fully authoritative and representative of United States opinion, hinges on the validity of its technical premises, they merit further investigation.

These technical premises were recently reviewed by Richard Bradfield, Head of the Agronomy Department, Cornell University, New York, who is well recognized as a fair-minded, well-travelled and able man. Speaking at a symposium on "Food" to the Academy of Political Sciences, Columbia University, New

*THE UNITED STATES SOIL CONSERVATION SERVICE

The Soil Conservation Service (S.C.S.) maintains teams of soil conservation experts who work throughout the entire country helping state extension (advisory) staff to organize soil conservation practices.

The S.C.S. was formed in the mid-thirties when it had an annual expenditure of about $10,000,000. To-day it costs about $40,000,000 per annum—a figure which is considerably less than its peak expenditures in the late thirties and early forties. In 1948, its operational costs were $38,000,000, whilst government payments to farmers and others for soil, water and other conservation and land improvement practices brought the total Federal expenditure on conservation to some $400,000,000. In its earlier days it was and still is, to some extent, a method of subsidizing agriculture. The S.C.S. has some 12,000 employees, of which 360 are primarily engaged in research.

York, he pointed out that the raw materials of soil (pulverized rock, air and water) are "the most abundant and cheapest on the face of the earth",* and are, ultimately, the source of the humus "which coats the tiny grains into which the pulverized rock ultimately becomes weathered".

Too much or too little "Sense of Humus"?

This humus is, in effect, the main bone of contention. Apart from its action as a sponge in equalizing the supply of water and plant nutrients and in favouring microbiological action, a humus-rich soil is, of course, normally much more resistant to water or wind erosion than a soil containing little or no humus. Crops which are grown in widely spaced rows (e.g. cotton, maize, soybeans, potatoes), not only leave more soil surface exposed to erosion but do not build up humus. Close-growing crops, like grass and legumes and to some extent wheat and oats and other small grains, not only reduce the exposed soil surface but help to build up humus. In the main agricultural areas of the United States (except the Great Plains) row crops (i.e. widely-spaced crops), are the major basis of farm income. They are generally more profitable than grass and clovers (which can only be used by feeding to livestock) or small grains. There is thus a strong temptation to grow too many row crops, even when this results in severe erosion, because a sound rotation of wide and close-growing crops would tend, many farmers contend, to reduce their income.

The Conservationists deny this. They point out firstly that, in many cases, the adoption of sound humus-building crop rotations has doubled or trebled the yield of the major cash crop (e.g. cotton or potatoes), and that, even if the humus-building crops, grasses and legumes yielded nothing, the extra yield on the cash crop would make soil conserving rotations profitable.

Secondly, the Conservationists argue that if soil conservation is not practised, the soil is washed away and lost as a national asset or blown away and literally "gone with the wind".

The Moderates and, more particularly the soil scientists, regard these claims as excessive.† On the first point they admit that humus-building increases yields. But they point out that in the Southern United States and in hot climates generally, the high summer temperatures rapidly oxidize away the humus; that unless the soil is covered in winter by a close-growing crop, much of the available plant nutrients, particularly nitrogen, is, in the Southern United States, leached away by the heavy winter rains on the bare land; that it may be more profitable to rely on heavy dressing of artificial fertilizers to cash crops; and that it may be better to control erosion, if that is necessary, by purely physical means. A cropping policy of this type is in fact very largely followed by many farmers in the South (Louisiana, Alabama, Mississippi) whilst in large parts of Florida there is practically no humus in the soil, which is then treated by the farmer as though it were a sand culture.

As to the second point, the soil scientists state that soil which is washed or blown away is not necessarily lost and gone forever. Bradfield, for instance, disputes a statement by the Conservationists that the soil on over 1,000,000,000 acres in the United States has been essentially destroyed or is subject to "destructively active" erosion. (This is 2½ times the total crop area of the United States but includes range land, forest and desert.) If erosion is as bad as these figures imply, why is it, Bradfield asks, that United States crop yields have in recent years been so outstandingly good?

The answer, which he does not supply, seems to be that the use of fertilizers, irrigation, the advent of hybrid corn (maize) and other gifts from the plant breeders, the greater use of agricultural chemicals to control insects, plant diseases and weeds, and the way in which mechanization helps the farmer to beat the weather by doing the job quickly at the right time have, taken together, substantially more than offset any loss of crop yields attributable to the wastage of topsoil by erosion.

Is Mild Erosion Beneficial?

Continuing, Bradfield shows that many of the best soils in the United States (e.g. the Mississippi Delta and those of the irrigated valleys in the Rocky Mountains) were formed and are still being formed by erosion of topsoil from land which is too rocky, too high or too dry to be cultivated. Even in less extreme cases, topsoil lost from an upland field or farm does not *all* get into the rivers—though the colour

* Proceedings, Academy of Political Sciences, Vol. XXIV, 2. January, 1949, New York.

† Bradfield points out that the most ardent soil conservationists are naturalists and ecologists and not soil scientists.

of many United States rivers is visible evidence that a great deal does—for some of it is deposited on lower fields or lower farms which are generally easier to work than upland farms.

Further, even when the topsoil has been washed away, the underlying subsoil is, in the United States, usually as rich in all plant nutrients (except nitrogen and sometimes phosphorus) as the "lost" topsoil; indeed, Bradfield argues, "there is some evidence that a moderate amount of erosion . . . is actually beneficial". It is a way of rejuvenating the soil and of utilizing the enormous reserves of plant nutrients in the subsoil.

Against this line, the Conservationists have claimed that it takes "300 to 1,000 years or more to bring back one inch of topsoil" by regenerative processes. But Bradfield replies, "experiments in which the entire topsoil has been removed by erosion" have shown that provided enough subsoil remains, it can, by economically feasible systems of management, be made to produce yields well above the average for the country. For instance in Ohio in 1936, all the top soil (to plough depth) was removed from a block of land, the subsoil of which was then limed, fertilized, and put into humus-building rotations. Within four years the yields of maize on this land were (at 70 to 80 bushels p.a.) more than double the United States average. Similar examples could be quoted from other areas in the United State. These considerations lead Bradfield to the conclusions that the dangers of soil erosion, though great, should not be over-emphasized and that, if by the use of the better farming practices mentioned above, the yields of all United States farmers could be brought up to those of the best ten per cent, then the farm output of the United States would increase 50 to 75 per cent.

This is probably true, and is, paradoxically enough, probably the Conservationists' trump card. For, though it may be difficult to show that soil conservation *per se* is profitable to the individual, there is little doubt that soil conservation has catalysed better farming. American farmers co-operating in soil conservation districts benefit from detailed surveys and individual production programmes for their farms and from "personalized" technical advice which usually persuades them to use better adapted crop and grass varieties, correct fertilizer applications, etc.

Like propaganda for the use of phosphate in the T.V.A. region, of lime in Kentucky, of stubble-mulching in the Great Plains, the soil conservation programme provides a simple appeal upon which to hang a programme of "better farming" which has paid and is paying good dividends. Thus, the indirect and incidental benefits of soil conservation have probably been as great to the individual as the direct benefits of soil erosion control. In other words, soil conservation may, in excess, be a bad master but, if used discreetly, it can be a good servant that makes a better master.

The Engineer's Approach.

The ecological aspects (i.e. the use of humus-building rotations and of close-growing crops which reduce surface erosion, etc.) have been discussed above because it is round them that most technical controversy centres. The engineering aspect, on which there is a much wider area of agreement, is equally important. This is partly (*a*) because eroding soils have less ability to "sponge" up rainfall, which therefore runs off immediately and substantially contributes to silting up or scouring of rivers and to the flood disasters which frequently "hit the headlines" in the United States press, and (*b*) partly because both sides agree that terracing, grass runways for water, contour farming, strip farming, stubble-mulch farming and other mainly physical or engineering methods of keeping the soil in place are technically and economically sound.

Further, the engineering approach appeals more directly to the American mind, which is more machine conscious and less biologically inclined, than the British. To many American farmers, soil (which he calls "dirt") is an inert commodity which you can shift around with a bulldozer; to most British farmers it is a living thing which needs the same care and attention as the crops it grows. The United States farmer is a good engineer; the British a good ecologist.

Conclusion: Advanced Countries

It is difficult, on such a highly technical and controversial subject, for the outsider to reach a fair conclusion. My personal conclusions, based primarily on my five years' experience in North America are, however, broadly as follows.

In North America, in spite of continued soil erosion, agricultural output in recent years has been increasing at about three per cent per annum. This is a high figure which is, so far as I know, only equalled in the United Kingdom. But this fact and the evidence discussed

above does seem to justify the conclusion that, provided physical means are taken to reduce excessive loss of soil, then the impact of modern science and industry on agriculture can continue to increase food production at a much greater rate than productivity is lost through soil erosion. In other words, advanced industrial countries or farming countries in a position, like New Zealand, to make use of modern scientific and industrial techniques need not fear starvation or even a reduced standard of living as a result of soil erosion provided that the soil is not wilfully wasted by profligate farming methods.

Conclusion: Less Developed Countries

On the other hand, those countries where the population is growing rapidly, where every available acre has to be heavily cropped and which are unlikely for many years to come to be able to apply modern science and industry to agriculture, have a great deal to fear from soil erosion. High soil temperatures, the difficulty of sparing acreage for humus-building non-food crops, the need to use crop wastes (e.g. straw) for fuel, housing, etc., may combine to make it almost impossible to adopt ecological soil conservation techniques. Inertia, ignorance and archaic land tenure systems (and possibly lack of heavy soil moving equipment) may make it difficult to apply engineering methods to keep the soil where it belongs, viz. on the farms.

Under these conditions, soil conservation practices on the American model may be impossible of attainment. Whilst, therefore, it is not suggested that soil erosion control should be neglected, it should never be regarded as an end in itself. It would seem better to concentrate at least as much attention on raising yields and output. This would be done, of course, by using more fertilizers, agricultural chemicals, improved husbandry techniques and improved plant varieties and, when possible, by bringing more land into cultivation by irrigation, bush clearing and similar reclamation schemes.

American estimates* (most of which are admittedly very rough) imply that, if this was done everywhere, world average crop yields could be increased by 20 to 50 per cent and total world food output by 50 to 70 per cent. Experience shows, however, that, in less developed countries (whatever their potential natural resources) it is difficult to increase output at a greater rate than 1½ to 2 per cent per annum, i.e. approximately the rate at which the expanding population of these overcrowded countries is growing.

Thus, if this analysis is correct, the main threat to these countries is perhaps not so much soil erosion, as the Conservationist school suggests, but their difficulty (which may be variously due to poverty, ignorance, apathy, ill-health or the lack of capital or of export crops with which to buy fertilizers, etc.) in applying modern scientific and industrial techniques to food production.

By aiming at higher yields it would be found, in many cases, that better husbandry and some ecological soil conservation were valuable by-products. In any case, without higher yields of food crops, it would politically be difficult to induce peasant farmers to spare acreage for soil conserving non-food or indirect food (e.g. forage) crops.

The moral (at least to me) is obvious. As soil conservation and food production cannot be divorced, they might as well work as partners. Otherwise their marriage will not only be unhappy but sterile in terms of human progress.

* *See* Spengler, T. T., "The World's Hunger—Malthus, 1948". Proceedings, Academy of Political Sciences, Vol. XXIII, 2. January, 1949, New York.

REVIEWS

AFRICANS AND THEIR LAND.—*A series of seven booklets by Norman Humphrey. Published by Highway Press, Nairobi, and Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, London, W.1. Written in English and Kiswahili with numerous illustrations.*

The aim of these booklets is to explain the reason for much that was done of old and for much that needs doing to-day. Book I, "The Land and its Problems", gives a simple description of how soils are formed by weathering of rocks, and how the soil is divided into layers from the organic topsoil to the rocky subsoil overlying the parent rock. The reasons for shifting cultivation are explained, and the misuse of land caused by insufficient resting of the soil under bush fallow is shown in relation to the increase in population due to better living conditions. The theme of the book is not to condemn the African for exhausting the soil, but to explain to him why it is that agricultural practices which were quite suitable under primitive living conditions, with constant pruning of the population by wars, disease, infant mortality, and periods of famine, are not suitable when the standard of living begins to rise.

Book II begins with a description of the methods of shifting cultivation which were successful before there was severe pressure of population on the land, and comparison is made between the bush fallow of some tribes and the natural grass fallow of others. This leads to a discussion of the benefits of a fallow of planted grass, which can shorten the resting period to three or four years. These planted grasses can withstand careful grazing during the resting period, so it can be used as a grass ley rather than fallow. The methods of disposal of waste plant residues, burning and burying, are compared in their effects on crops and soils. Rotation and soil conservation by strip cropping is shown to benefit both soil and crop, and mixed cropping, by interplanting legumes with cereals, is a means of protecting the soil from sun and rain, and of raising its nitrogen content.

Book III points out that one of the chief weaknesses of African agriculture in the past lay in the fact that crops and stock were treated separately, and not as parts of a combined system of agriculture. As a result, the dung-heap was regarded as of little value, except in so far as it showed a man to be rich in cattle. This attitude, though general in East Africa, was not universal, since some tribes, through severe shortage of land, had learned to appreciate, to some extent, the benefit of applying manure to to crops. One tribe even went so far as to develop a system of preparing a cattle manure compost with considerable care. Fortunately there is a growing realization of the value of animal manure, but there is still a great need for the linking of stock and crops on the farm. Large areas are still uninhabitable by cattle because of tsetse fly, but in the fly-free areas it is vitally important that balanced systems of mixed farming should be developed and applied, in order to raise the fertility of the land. Stall-feeding and compost-making are described and recommended as being financially worth while.

Book IV describes the causes of soil erosion and the ways in which this can be prevented, but it also describes soil conservation methods which some tribes have worked out for themselves, or have adopted when their value was demonstrated in the field. It is encouraging to find that many Africans do value their soils and are prepared to take trouble in conserving them and maintaining their fertility. These are usually in areas which have been over-populated for many years, so that the inhabitants have had to fight for survival. It is possible that these lands passed through a phase of serious erosion and soil exhaustion and that the natives had to learn their agricultural lessons the hard way. On the other hand, these carefully cultivated lands are nearly always in places which slave-raiders could not easily reach, and the sense of fear may have been a strong incentive to making the best of what little land was available. Nevertheless, it shows that the African can be a good farmer, and it raises high hopes that those areas which are now threatened with destruction may be saved by a change of attitude in the inhabitants.

Book V begins by showing the effect of forests on water supplies, and emphasizes the necessity for the headwaters of streams and rivers to be protected by trees in order to ensure a steady supply of clean water. Some African communities have realized the importance of this, and have devised their own simple methods of forest control, but on the whole, Africans, like many Europeans, have looked on trees as something provided free of charge by a benign Providence. The care of

forests is specialized work, and now the Forest Departments are taking charge of native forest reserves, and are working them by scientific methods which give the maximum yield of wood with the maximum protection to soil and water.

This book is probably the most important of the series, since it deals with a subject which is seldom taken seriously by farmers of any race. The best farming methods will be of no avail if the neighbouring forests are cut down and the water balance of a region is disturbed, but it is only by communal effort and care that the evils of deforestation can be avoided.

In Book VI the need is emphasized for balanced farming in relation to food for the farmer himself and his family. One-crop farming, such as is common in the maize-producing districts, leads to a vegetarian diet which is not sufficient for health. At the other extreme, the pastoral tribes, such as the Masai, who live entirely on meat, blood and milk, although they are stronger than the vegetarian tribes, also suffer from deficiency diseases. Where a mixed diet is possible, including animal as well as vegetable products, the difference in health and strength is very noticeable. Emphasis is also laid on the importance of leafy vegetables to provide "protective foods".

A simple explanation is given of the function of the different components of a good diet, and although this is a complicated subject to explain simply, the scientific points have been cut down to a minimum, and an African with reasonable schooling should be able to follow the subject.

Book VII, dealing with balanced farming, is divided into two main parts, the first dealing with crop rotation, in which a field is planted to a suitable succession of crops, followed by a resting period under grass. The variation in crops provides a better diet, while the period under grass is used for grazing of animals. By rotating the crops, no severe strain is put on the soil, and at the end of the cropping period it is able to produce good grass for grazing. Care in planting good grass for the fallow period is repaid by the increased amount of grazing available.

The second half of the book describes how much better it is to have a few good quality cattle rather than a number of thriftless, low-grade animals. While the less-developed tribes will be reluctant to change from their old system that a large number of cattle, irrespective of quality, is a symbol of wealth, the more progressive African farmers, in districts which are over-populated, are becoming cash-conscious, and they will soon see the value of a few good quality animals. Tribal customs cannot be changed overnight, but some tribes are already adapting themselves to new conditions, and where land is scarce, intelligence is sharpened.

D.W.D.

THE JOHN INNES GLASSHOUSES.—Published by the John Innes Horticultural Institution, Bayfordbury, Hertford, Herts, England. Price 1/-.

Few horticulturists in East Africa grow their plants in glasshouses; but those few will be interested in recent developments at the John Innes Horticultural Institution. When this Institution moved from its original site at Morton to Bayfordbury in Hertfordshire the opportunity was taken to scrap a range of glasshouses of different designs and constructional materials. The present short paper describes these houses and devices adopted to improve lighting, ventilation, temperature and humidity control.

THE PRODUCTION AND UTILIZATION OF SILAGE. —A Review of World Literature in Abstracts. Bulletin No. 40 of the Commonwealth Bureau of Pastures and Field Crops. Published by the Commonwealth Agricultural Bureaux, Penglais, Aberystwyth, Wales (1950), pp. 309. Price 10/-

It is not usual to recommend a book of abstracts to farmers, but this volume deserves study by anyone who is interested in the manufacture of silage. Many of the abstracts are sufficiently detailed to be of practical value, but the book is a review of the principles rather than a summary of the practice of silage production. As a reference book for technical officers it is of great value, with abstracts from 969 papers which have appeared in scientific journals throughout the world during the past 15 to 20 years.

D.W.D.

ELEMENTARY FORESTRY, By W. J. Eggeling (Conservator of Forests, Uganda), 2nd Ed. (1949). Ballière, Tindall & Cox, London, pp. xvi + 307.

This useful little book has been written in collaboration with the staff of the Uganda Forest Department, and this second edition of it is revised, expanded and brought up to date by R. G. Sangster, the Senior Assistant Conservator of Forests, Uganda. It is one of Ballière's elementary tropical handbooks and is intended for the training of the local forest staff in the elementary facts of plant life, the soil, simple forestry and the working of the Forest Department. The students for whom it is meant have usually only a limited knowledge of English and hence the book has been kept as simple as possible.

The ground it covers is very wide, as can be seen from the chapter headings, Forestry, Soil, Simple Botany, Demarcation and Survey, Protection, Management and Exploitation, Introduction to Silviculture, Regeneration, Nursery Work, Formation, Tending, Notes on the Silviculture of some Important Species and Administration. In addition there are appendices on general information volume tables, a glossary of common and vernacular names and a wages table. The authors are to be congratulated on having produced so much in such a small compass without giving the reader a feeling of "mental indigestion". Although primarily intended for Uganda students it will be of value not only throughout East Africa but also in many other parts of the tropics.

The indirect value of forests which is so often either not understood or else ignored by governments and peoples alike is greatly stressed and it is of particular interest to note that in a special announcement by His Excellency the Governor in 1948 on Uganda's forest policy the first item of forest policy concerned the protection of forests and their indirect value to the country.

It is rather troublesome to the reader from outside Uganda that most of the scientific names are confined to the glossary but after all the book was not written primarily for such students. One would however have liked to see a more consistent procedure followed. For example, in the notes on the silviculture of some of the important species, scientific names are given for some species and not for others.

A further small suggestion is with regard to the use of the expression "the pretreatment of seed" (p. 172). The book is intended for those with only a small knowledge of English and it is suggested that the more usual term "pre-sowing treatment" of seed would be more easily understandable.

The book is well produced and clearly printed but it is to be regretted that some photographs of Uganda's forests and trees were not included. Such an addition would make the book more living.

This excellent book should find a place in many schools and colleges throughout the tropics and it can be thoroughly recommended as being both simple and readable.

A.L.G.